Chapter 13

Geology, Soils, and Paleontological Resources

13.1 Introduction

This chapter describes the impacts related to geology, soils, and paleontological resources that would result from construction and operation of each of the build alternatives. The sections that follow describe the study area, the methods used to analyze the impacts, the affected environment, and the impacts of the build alternatives on each of the following resources.

- Section 13.2, *Geology and Soils*
- Section 13.3, *Paleontological Resources*

The regulations and guidance related to water resources are summarized in Section 13.4, *Applicable Regulations*. The contribution of the proposed rail line to cumulative impacts related to geology, soils, and paleontological resources is discussed in Chapter 18, *Cumulative Impacts*.

13.2 Geology and Soils

This section describes the impacts related to geology and soils that would result from construction and operation of each of the build alternatives. The sections that follow describe the geology and soils study area, the methods used to analyze the impacts, the affected environment, and the impacts of the build alternatives related to geology and soils. The regulations and guidance related to geology and soils are summarized in Section 13.4, *Applicable Regulations*. The contribution of the proposed rail line to cumulative impacts related to geology and soils is discussed in Chapter 18, *Cumulative Impacts*.

In summary, the Decker Alternatives would have the steepest slopes, move the most earth for construction, and have the least suitable soils for construction. The Tongue River Alternatives would have the least steep slopes, move the least earth for construction, and have the most soils suitable for construction. OEA concludes that adverse impacts would range from negligible to minor, depending on the build alternative.

13.2.1 Study Area

OEA defined two study areas for geology and soils. The first study area captures the broad scale of geologic features that could contribute to seismicity (risk of earthquake). OEA based this study area on the geologic features of southeastern Montana, the region through which the proposed rail line would travel. The second study area is localized and captures immediate risks to the proposed rail line from topography and soils or impacts on soils and topography from the proposed rail line. This study area for topography and soils is the rights-of-way of the build alternatives.

13.2.2 Analysis Methods

OEA used the following methods and information to evaluate the impacts of construction and operation of the proposed rail line on geology and soils.

OEA analyzed potential impacts related to geology and soils qualitatively, based on a review of available published literature, topographic resources, and professional judgment. The available resources included aerial photographs, geologic and topographic maps and other publications by the U.S. Geological Survey, and soil surveys and mapping by the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS).

OEA's analysis focused on the following risks to the build alternatives, and impacts of the build alternatives on soil and geology.

- Physical alteration of the existing topography.
- Construction on unsuitable geologic formations.

- Construction on unsuitable soils.
- Soil or topsoil loss through erosion.
- Construction in an area of seismic hazards.

The specific analysis methods for topography, geology, soils, and seismicity are discussed in the following subsections.

13.2.2.1 Topography

OEA performed a topographic analysis to identify and compare the extent to which the proposed rail line would require modifications to the existing topography. The proposed rail line would be designed to meet current main line standards, including the *ruling grade*[1] requirement (the steepest slope at which a train can operate under normal conditions), while minimizing cuts and fills. OEA analyzed the topography along each build alternative, using a 10-meter digital elevation model to calculate slope. This model does so at small intervals, thereby accounting for unique topographic features that would be lost in a method that averages slope values over long distances.

13.2.2.2 Geology

OEA reviewed available literature to determine which geologic formations occur in the geologic study area. OEA mapped these geologic formations in relation to the build alternatives. OEA then identified areas along the rights-of-way where bedrock formations would need to be removed, modified, or tunneled through to construct each build alternative or access roads, and where nearby and suitable bedrock formations could be mined for construction material.

13.2.2.3 Soils

OEA conducted a soil analysis along and within the rights-of-way to identify soils unsuitable for construction. These soils would need to be removed or remediated before construction. Unsuitable soils are either unstable; e.g., subject to *slumping* (movement down a slope) or *slope failure* (landslides), or do not have favorable geochemical properties; e.g., are *sodic* (high concentration of sodium) or *hydric* (anaerobic).

OEA performed this analysis by evaluating the physical and geochemical characteristics of the soils in the rights-of-way using the NRCS STATSGO database. The STATSGO database is a digital soil map that identifies a broad-based inventory of soils and nonsoil areas in the United States, Puerto Rico, and the Virgin Islands. The level of mapping is designed for broad planning and management of state, regional, and multistate areas. It was developed by the National Cooperative Soil Survey and is managed and maintained by the USDA Natural

[1] Terms italicized at first use are defined in Chapter 25, *Glossary*.

Resources Conservation Service (Natural Resources Conservation Service 2014a). OEA considered the following STATSGO physical and geochemical characteristics.

- **AASHTO classification**. The American Association of State Highway and Transportation Officials (AASHTO) Soil Classification System is used as a guide for the classification of soils and soil-aggregate mixtures for highway construction purposes. The soils analysis was performed using applicable soil properties found in USDA's Soil Survey Geographic Database (SSUGRO). In lieu of a published standard or soil classification system for rail bed construction, OEA used the ASSHTO classification system for highway construction as a surrogate. While the loads and stresses imposed on a rail bed are significantly greater than the loads imposed on highways by vehicular traffic, the use of AASHTO provides a general indication of the suitability of the soils on the project alignment to support rail traffic.

  The AASHTO system classifies soils into eight groups, A-1 through A-8. Groups A-1 through A-3 represent coarse-grained soils with group A-1 representing the best subgrade. Groups A-4 through A-7 represent fine-grained soils comprise fair to poor subgrade material. Group A-8 consists of peats and mucks and is unsuitable for road construction and therefore for rail construction.

  The group classifications depend on three factors: sieve analysis, liquid limit, and plasticity index. Group A-1 materials are granular and group A-7 soils are silt-clay materials. Gradation is generally progressive from excellent subgrade rating (A-1) to poor subgrade rating (A-8) (U.S. Department of Agriculture 1987). OEA considered this soil characteristic to evaluate the soil association's general suitability for construction.

- **Concrete corrosion rating**. The concrete corrosion rating interprets the susceptibility of concrete to corrosion when in contact with the soil. Risk of corrosion pertains to the potential soil-induced chemical reaction between a base (the concrete) and a weak acid (the soil solution). The rate of deterioration depends on soil texture and acidity; the amount of sodium or magnesium sulfate present in the soil, singly or in combination; and the amount of sodium chloride present in the soil (Natural Resources Conservation Service 2014b).

- **Hydric soil rating**. The hydric soil rating indicates the presence of hydric soils. Hydric soils are soils that are sufficiently wet in the upper part to develop *anaerobic* conditions (without oxygen) during the growing season. Hydric soils may present engineering challenges because they may indicate that wetlands and drainage improvements would be required to support buildings, roads, and other facilities. OEA considered this soil characteristic to evaluate the soil association's suitability for railbed construction.

- **Linear extensibility**. *Linear extensibility* refers to the change in volume of a unit of soil as moisture content decreases. The volume change is reported as percent change for the whole soil; a higher percent represents a greater capacity to shrink or swell. OEA considered this soil characteristic to evaluate the shrink-swell behavior of soils in the topography and soils study area. Shrinking and swelling of soils cause damage to building foundations, roads, and other structures. A high shrink-swell potential indicates a hazard to structures built in, on, or with material having this rating. The amount and type of clay minerals in the soil influence volume change. Generally, a change of less than 3 percent indicates a low linear extensibility; a change from 3 to 5.9 percent indicates a moderate linear extensibility; a change from 5.9 to 9.0 percent indicates a high linear extensibility; and a change of greater than 9 percent indicates a very high linear extensibility (U.S. Department of Agriculture 2014a).

- **Sodium absorption ratio**. The *sodium absorption ratio* (SAR) is a measure of the relative proportion of sodium *cations* to calcium and magnesium cations in a soil, expressed in the units of *milliequivalents* per liter. A higher SAR may result in unfavorable engineering and agricultural conditions. Soils having a SAR value of 13 or more are referred to as sodic soils. Sodic soils have the potential to be *dispersive*, meaning the soil loses its ability to clump into aggregates, thus making the soil susceptible to erosion, particularly on slopes subject to runoff.

  The amount of sodium is also an important factor in determining the soil's suitability for supporting trees and shrubs because sodium strongly influences water infiltration and soil aeration. A SAR greater than 13 suggests a likelihood of reduced soil permeability and decreased plant survival and growth rates, especially in fine-textured (clay) soils (U.S. Department of Agriculture 2014b).

- **Soil erodibility factor**. The soil erodibility factor quantifies the susceptibility of soil particles to detachment and movement by water. Values range from 0.02 to 0.69. Generally, the greater the value, the greater the susceptibility of the soil to erosion. Soils resistant to erosion typically have a soil erodibility factor less than 0.37 and easily erodible soils have a factor between 0.37 and 0.69. OEA considered this soil characteristic, combined with the relative slope gradient, to evaluate the erosion potential for soils in the topography and soils study area.

- **Slope gradient**. Slope can be expressed as the rise of the soil surface from horizontal (in degrees) or as the difference in elevation between two points (in meters), expressed as a percent. The second expression is referred to as *percent gradient* and is often used in road and rail engineering. Table 13.2-1 summarizes slope classes and gradient limits from USDA. Slope gradient is different from the slope calculated for the topographic analysis discussed in Section 13.2.3.1, *Topography*. The slope as used in the STATSGO database indicates a general gradient at which a particular soil type has been found to occur. It is not necessarily representative of the slope gradient in the topography and soils study area. OEA evaluated the erosion potential for soils in the topography and soils study area based on the STATSGO slope gradient and soil erodibility factor.

Table 13.2-1. Definition of Slope Classes

Slope Class (Simple)	Slope Class (Complex)	Slope Gradient Limits: Lower Percent	Slope Gradient Limits: Upper Percent
Nearly level	Nearly level	0	3
Gently sloping	Undulating	1	8
Strong sloping	Rolling	4	16
Moderately steep	Hilly	10	30
Steep	Steep	20	60
Very steep	Very steep	> 45	

Notes:
Source: U.S. Department of Agriculture 2014c

13.2.2.4 Seismic Hazards

OEA conducted a seismic hazard analysis to quantify the probability of surface fault rupture and seismic shaking. OEA evaluated seismic hazards by reviewing scientific literature regarding seismicity in southeastern Montana and reviewing maps of likely seismic hazards in the geologic study area.

13.2.3 Affected Environment

The existing environmental conditions related to geology and soils are described below.

13.2.3.1 Topography

The topography of southeastern Montana is characterized by hilly, rugged uplands interspersed with wide, rolling valleys. The proposed rail line would be situated in or near the Tongue River Basin, which is a subbasin of the Yellowstone River drainage. Elevation in the Yellowstone River Basin ranges from 1,800 feet above mean sea level (AMSL), where the Yellowstone and Missouri Rivers converge at the Montana/North Dakota border, to more than 12,000 feet AMSL, in the mountains of the Yellowstone River headwaters in Wyoming. Within the Tongue River Basin, elevation ranges from 2,350 feet AMSL, where the Tongue and Yellowstone Rivers converge near Miles City, to over 13,000 feet AMSL, in the Bighorn Range of Wyoming.

Between the mouth of the Tongue River and the foothills along the Big Horn Mountain to the southwest are plains. Locally, the Tongue River Basin is characterized by buttes capped by *porcellanite*, created by burned-out coal beds. Porcellanite is a sedimentary rock type made of silica. It is hard and dense and takes its name from its resemblance to unglazed porcelain. The hills and buttes generally rise 200 to 500 feet above the adjacent terrain. The foothills along the Big Horn Mountains rise approximately 2,000 feet above the plains, while the Big Horn Mountains rise approximately 13,000 feet AMSL. The western boundary of the basin is formed by the Wolf Mountains, a series of tree-studded hills as high as 5,000 feet, that run north from near the Wyoming border.

The major water feature in the basin is the Tongue River, which is fed by winter snow pack of the Big Horn Mountains and flows to the north to its mouth on the Yellowstone River. Downstream from the Tongue River Reservoir, located near the Montana/Wyoming border, the Tongue River is fed by numerous smaller streams, including Hanging Woman Creek, Otter Creek, and Pumpkin Creek. These tributaries contribute to the broken topography within the plains portion of the basin.

Rosebud Creek is not a tributary of the Tongue River; its headwaters are located in the Wolf Mountains near the Montana/Wyoming border and flow north-northeast and northwest to join the Yellowstone River near Rosebud. The Tongue River flows in a northeasterly direction and shortly before reaching Miles City, it turns to flow northwest to join the Yellowstone River. Figures 13.2-1a through 13.2-1d show the topography of the topography and soils study area and slopes within the rights-of-way of the build alternatives.

13.2.3.2 Geology

The geologic setting for the proposed rail line is within the Powder River Basin of the Great Plains *physiographic* province. The Powder River Basin, which is located in southeastern Montana and northeastern Wyoming, is a nearly 400-mile-long north-northwest trending structural basin. The *synclinal axis* of the basin, or the line from which the strata slope upward in opposing directions, is located nearer the western portion of basin; *stratigraphic units* on the east side of the basin dip gently to west and stratigraphic units on the west side of the basin dip more steeply to the east (U.S. Geological Survey 2013). Three geologic formations are present at or near the surface: Quaternary Alluvium, Quaternary Terrace Deposits, and the Tertiary Fort Union Formation. The following sections describe each of these formations. Figures 13.2-2a and 13.2-2b show surficial geology in the geologic study area.

Quaternary Alluvium and Terrace Deposits

These deposits consist of *unconsolidated* silt, sand, and gravel along the streambeds and terraces of the Tongue River and its tributaries. These deposits can reach a thickness of up to 130 feet.

Fort Union Formation

The Fort Union Formation is Paleocene in age (early Tertiary) and consists of three distinct members: the Tongue River, Lebo, and Tullock (listed in order of increasing age). The Fort Union Formation was generally deposited by *fluvial sedimentation* processes, although the inferred fluvial mechanism is thought to be somewhat varied between the three members. The Tongue River Member consists primarily of interbedded mudstone, silty shale, carbonaceous shale, and coal, with lesser amounts of siltstone fine-grained sandstone (Bureau of Land Management 2009).

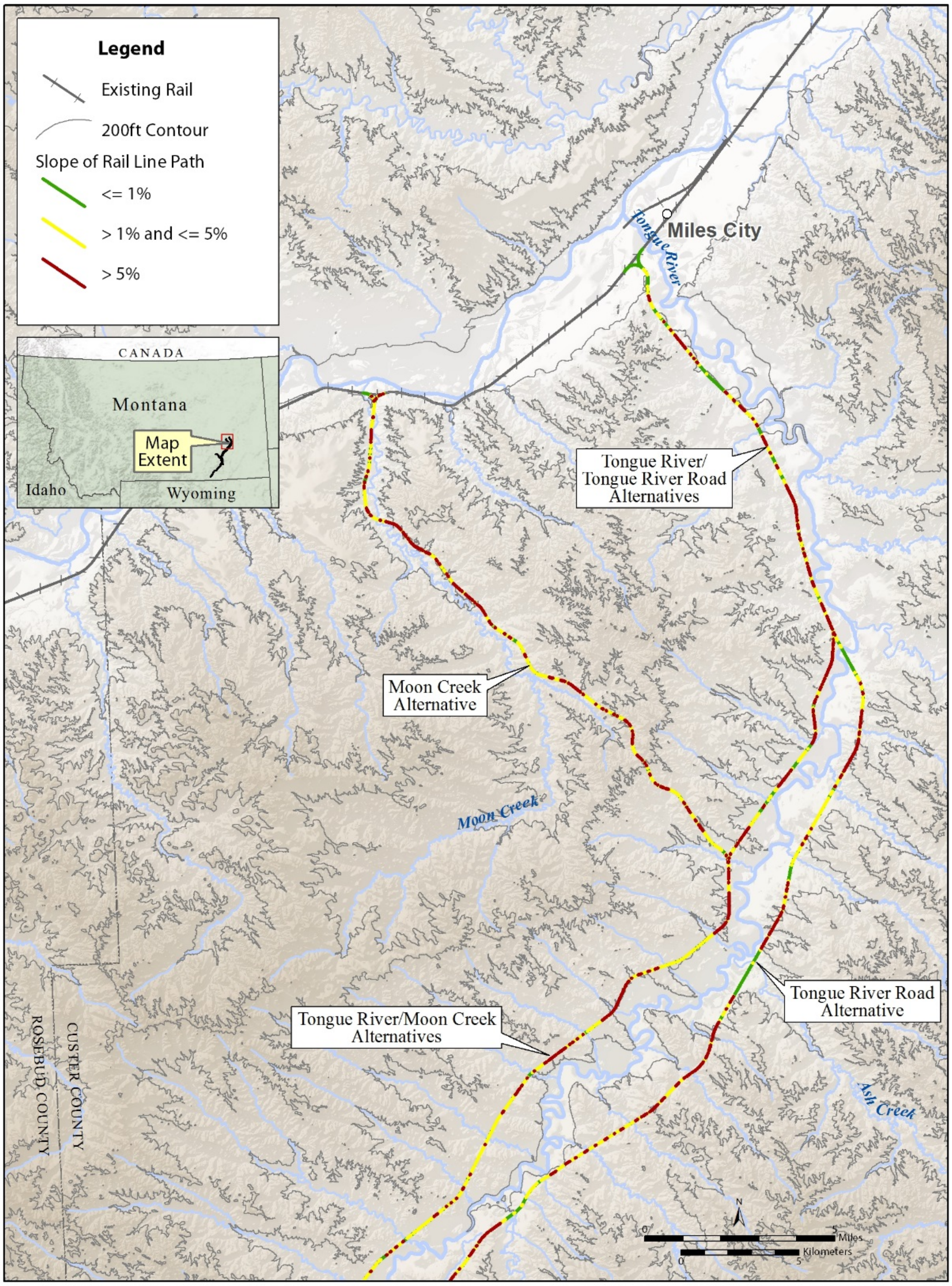


Figure 13.2-1a. Topography and Slope of the Build Alternatives

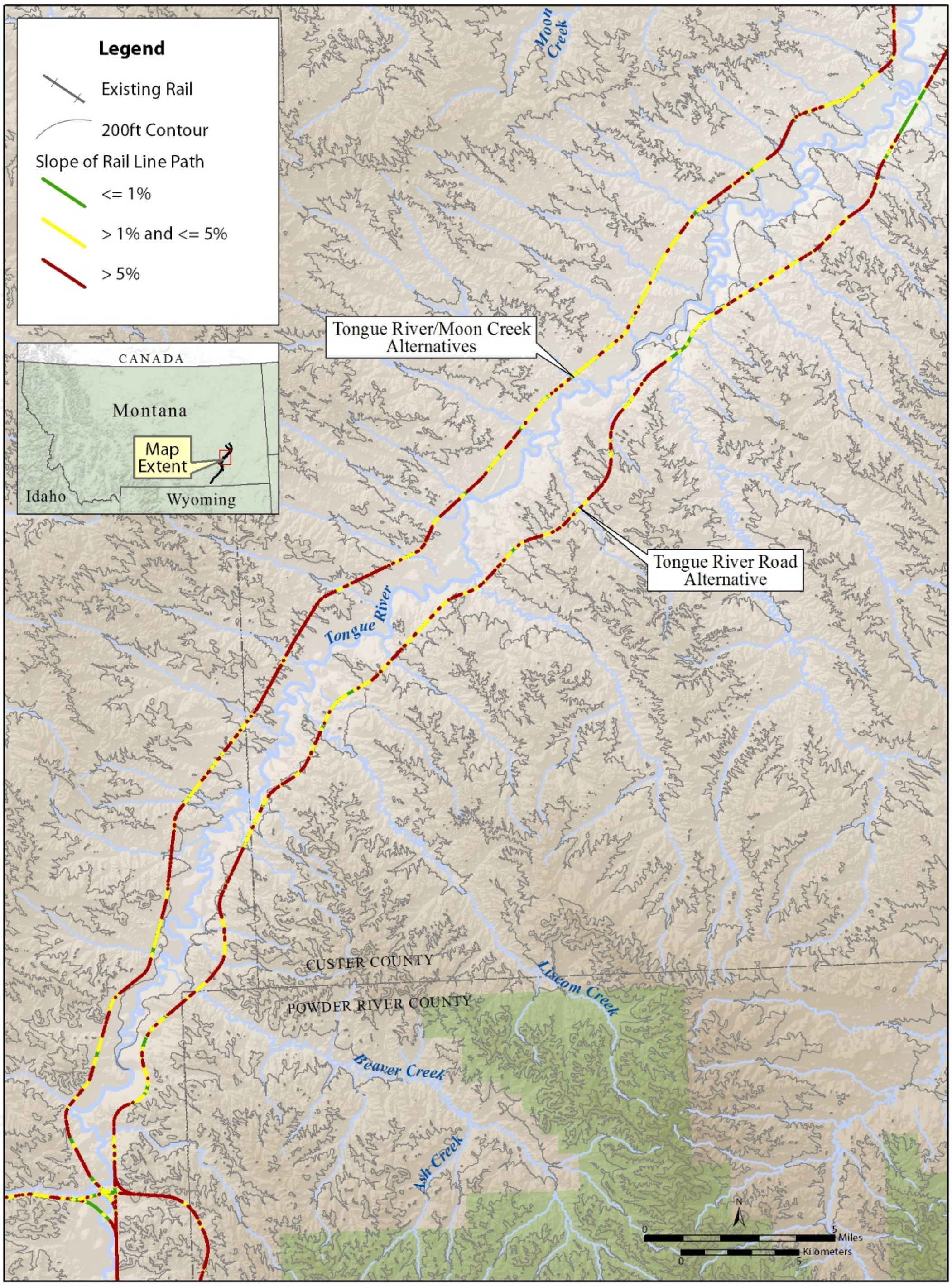


Figure 13.2-1b. Topography and Slope of the Build Alternatives

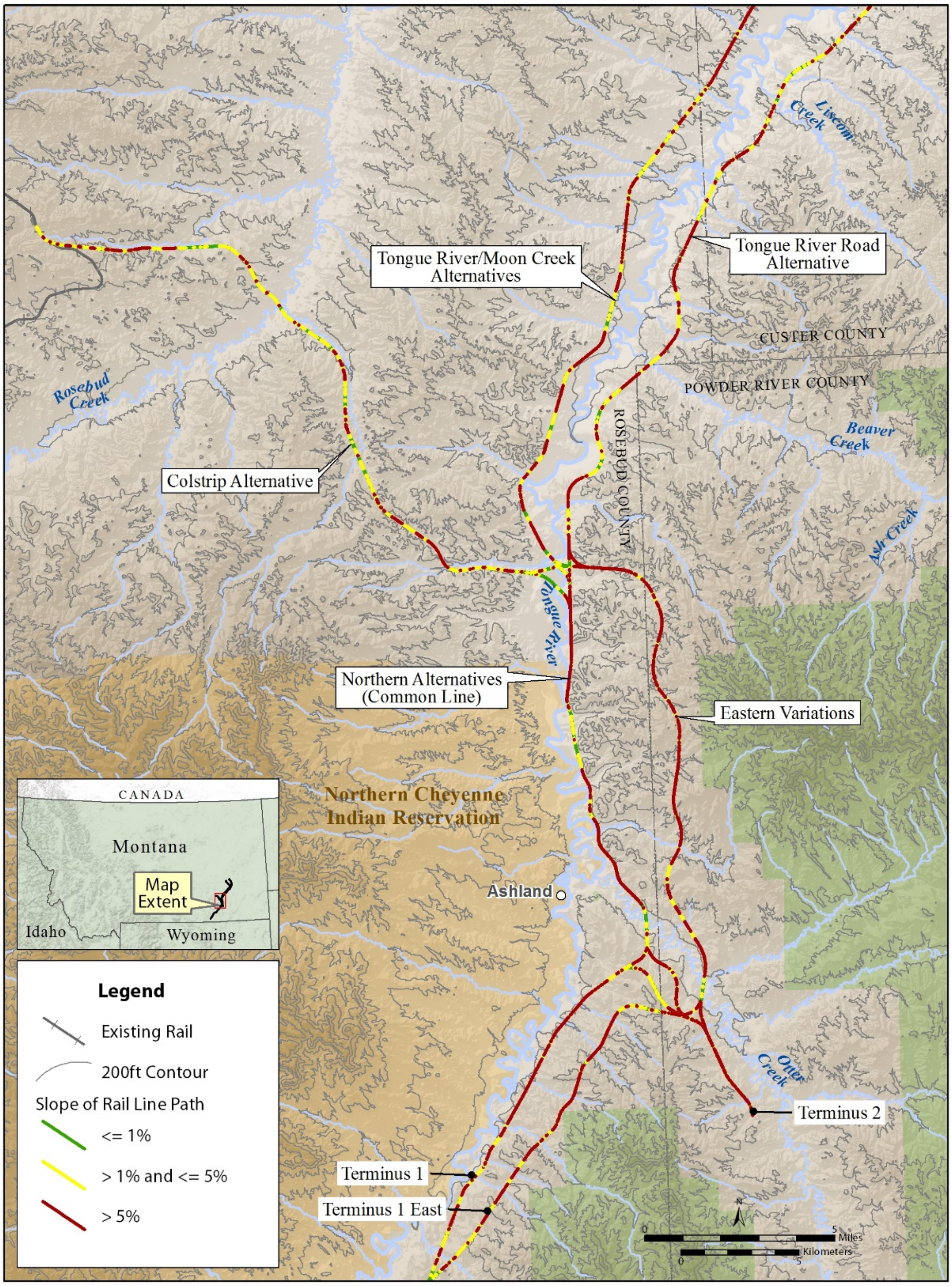


Figure 13.2-1c. Topography and Slope of the Build Alternatives

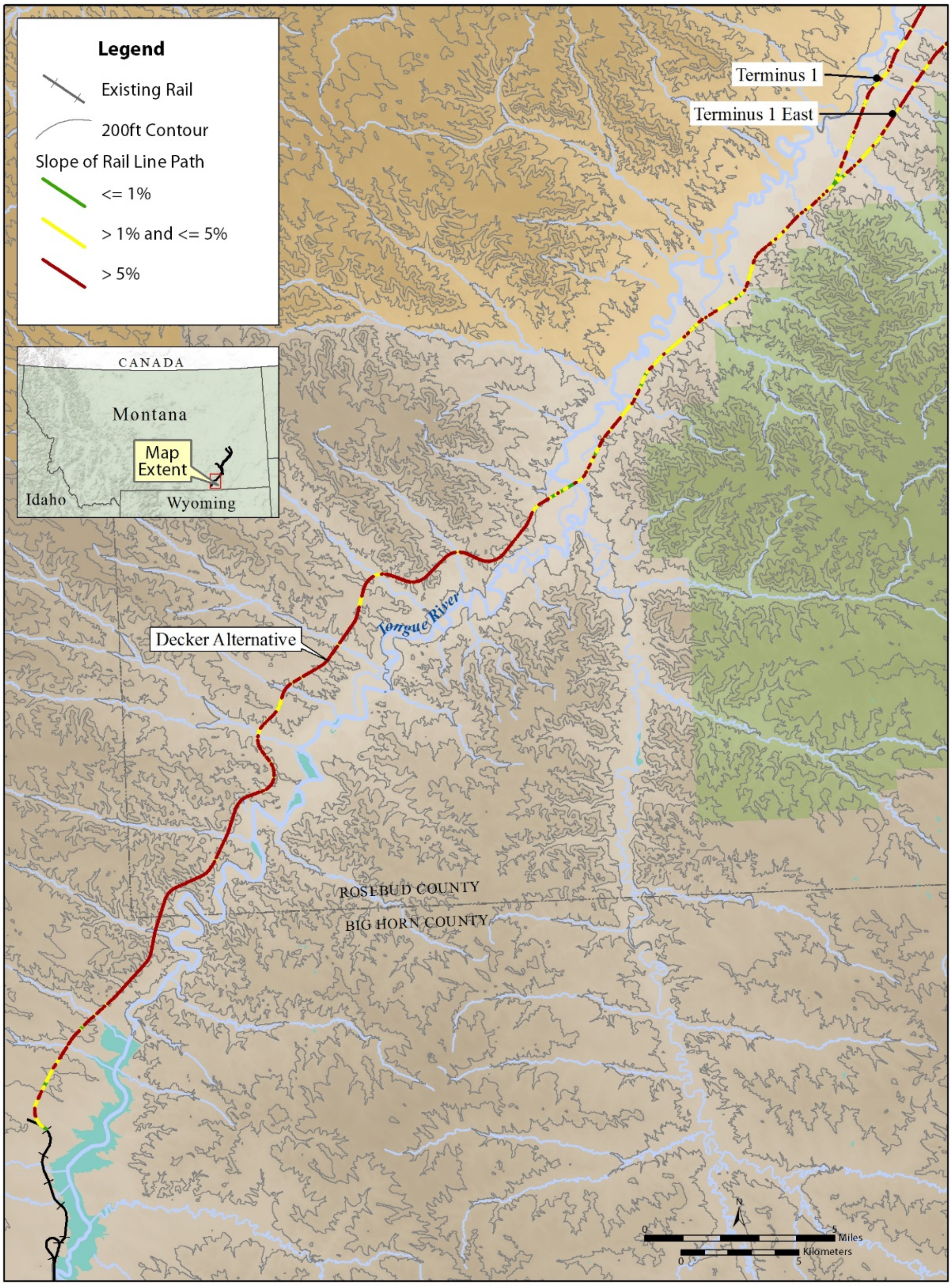


Figure 13.2-1d. Topography and Slope of the Build Alternatives

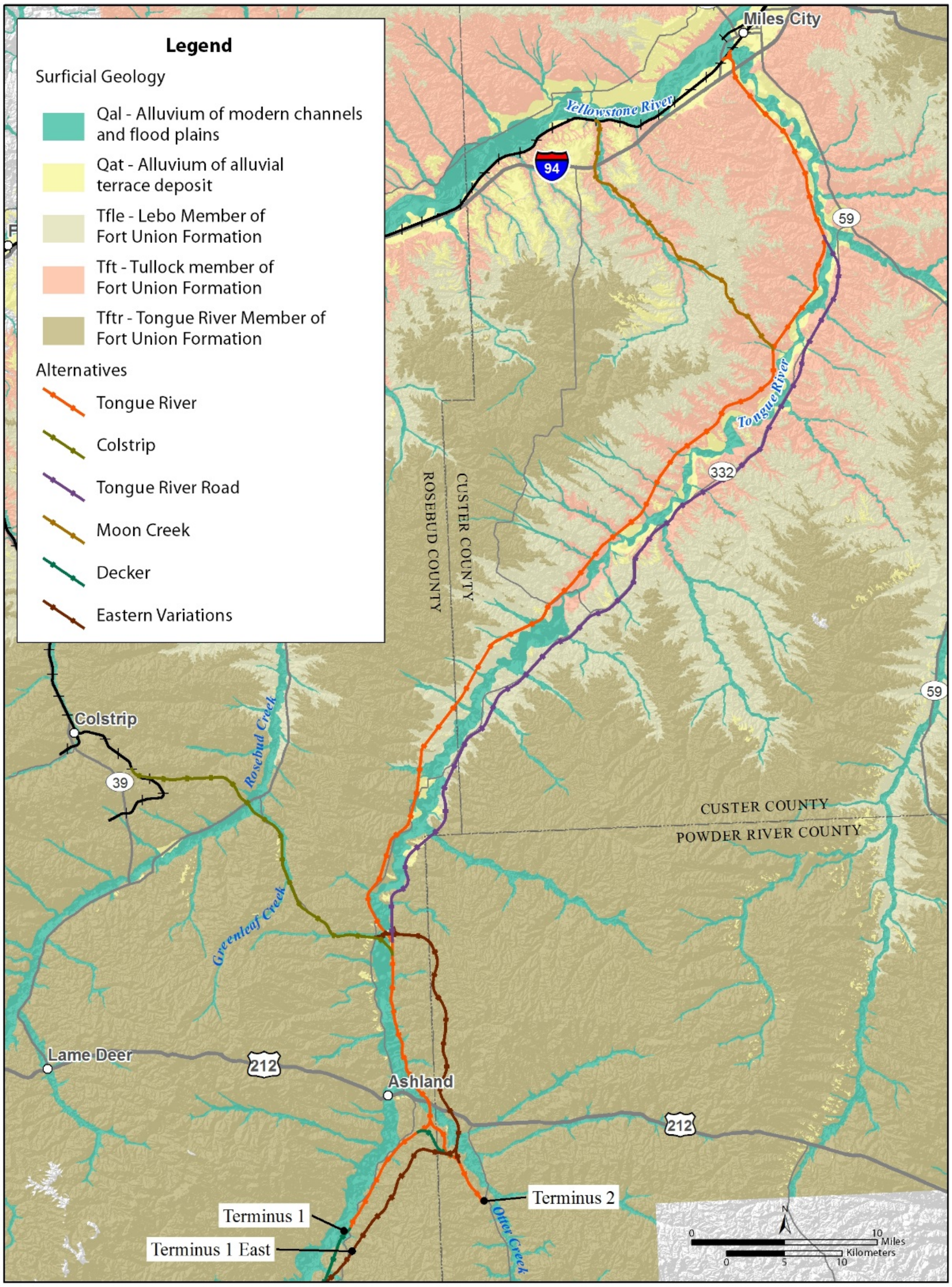


Figure 13.2-2a. Surficial Geology within the Study Area, Northern Alternatives

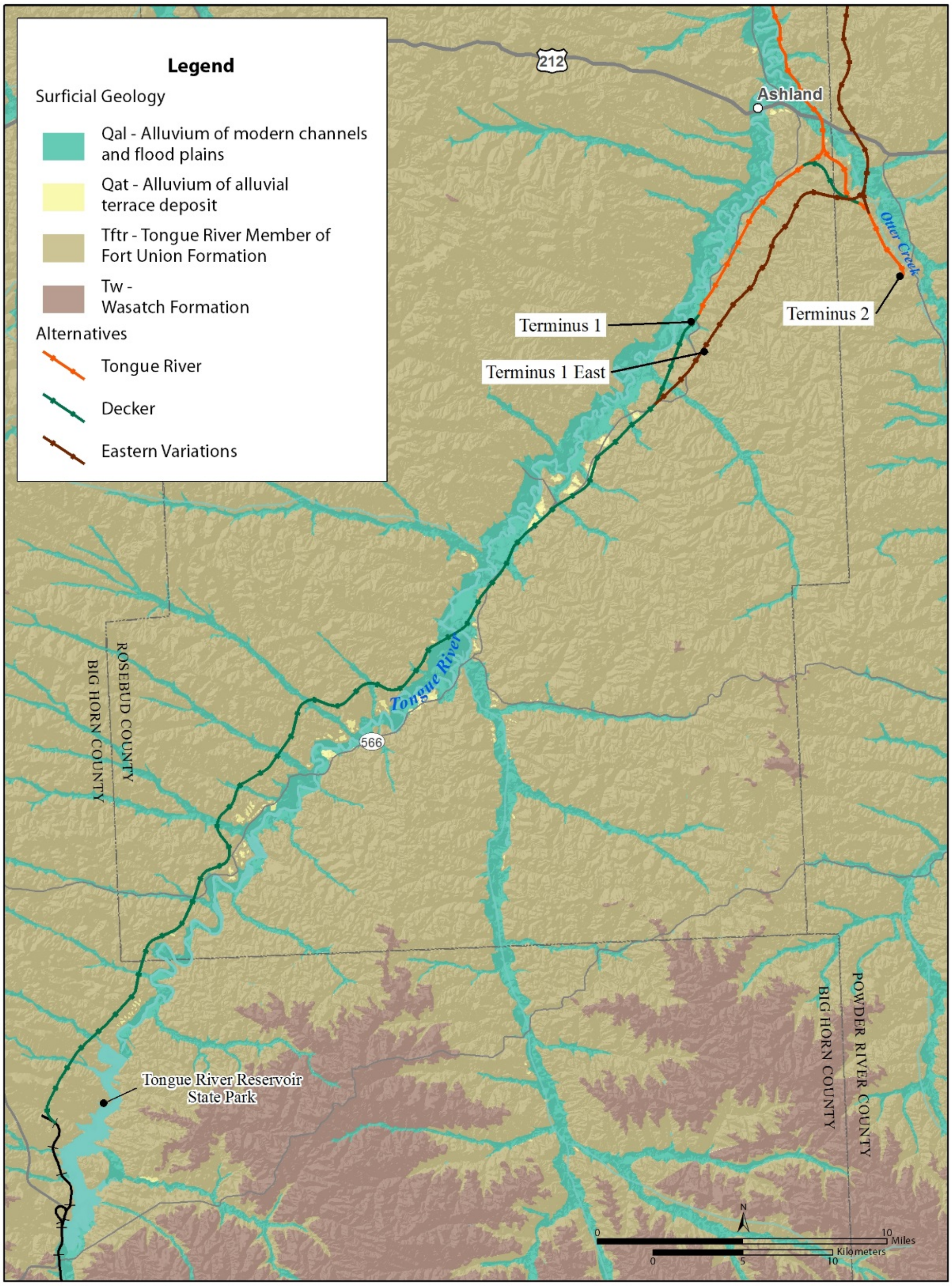


Figure 13.2-2b. Surficial Geology within the Study Area, Southern Alternatives

Coal beds in the Tongue River Member are abundant and range from thin layers (a few inches) to very thick layers (in excess of 200 feet) and have an average thickness of approximately 25 feet. The Wyodak-Anderson coal zone, a prolific source of coal in the Powder River Basin, is present in the Tongue River Member. The underlying Lebo Member, which is sometimes referred to as the Lebo Shale, is composed primarily of sandstone, siltstone, mudstone, shale, and coal (U.S. Geological Survey 2013). The Tullock Member is the oldest member of the Fort Union Formation.

Within the Powder River Basin, the Tullock Member reaches a maximum thickness of approximately 370 feet and 1,400 feet in the north and south, respectively. Compositionally, the Tullock Member consists of fine-grained sandstone, sandy siltstone, shale, limestone (very limited), and coal. The Tullock Member is an important regional aquifer for eastern Montana and serves as a source of low-sulfur coal for local consumption (Brown 1993).

13.2.3.3 Soils

OEA identified seven soil associations in the topography and soils study area based on NRCS mapping and soil data. Soil associations consist of two or more dissimilar components occurring in a regularly repeating pattern. Soil associations are a type of soil map unit, which is a unique collection of areas with similar soil components or miscellaneous areas or both. The major soil components in an association must be identifiable at the scale of the map. Table 13.2-2 summarizes the soil associations in the topography and soils study area and their geochemical properties; it does not include small bodies of soils with different characteristics. TRRC would conduct site-specific geotechnical and engineering studies when a build alternative is approved. Figures 13.2-3a through 13.2-3d show the distribution of the soil associations in this study area.

Table 13.2-2. Soil Associations in the Topography and Soils Study Area

Soil Association	ASHTO Class	Concrete Corrosion Rating	Hydric Soil	Linear Extensibility (%)	Sodium Absorption Ratio (meq/l)	Soil Erodibility Factor	Slope Gradient (%)[a]
Rock outcrop-Megonot-Manning-Cambeth-Cabbart	A-2	Low	No	1.5	0	0.24	12
Spinekop-Kobar-Havre	A-4	Low	No	1.5	0	0.28	1
Yamac-Delpoint-Cabbart	A-6	Low	No	4.5	0	0.37	39
Yamac-Havre	A-6	Low	No	4.5	0	0.32	1
Yamac-Kirby-Cabbart-Birney	A-6	Low	No	4.5	3	0.37	9
Yawdim-Thurlow-Cabbart	-	Low	No	0	0	-	27
Zigweid-Yawdim-Nuncho-Havre-Haverdad	A-6	Low	No	4.5	0	0.37	8

Notes:

[a] The slope gradient soil attribute as used in the STATSGO database indicates a general gradient at which a particular soil type has been found to occur and does not represent the actual slope within the topography and soils study area.

Source: U.S. Department of Agriculture 2014d

AASHTO = The American Association of State Highway and Transportation Officials; meq/l = milliequivalents per liter

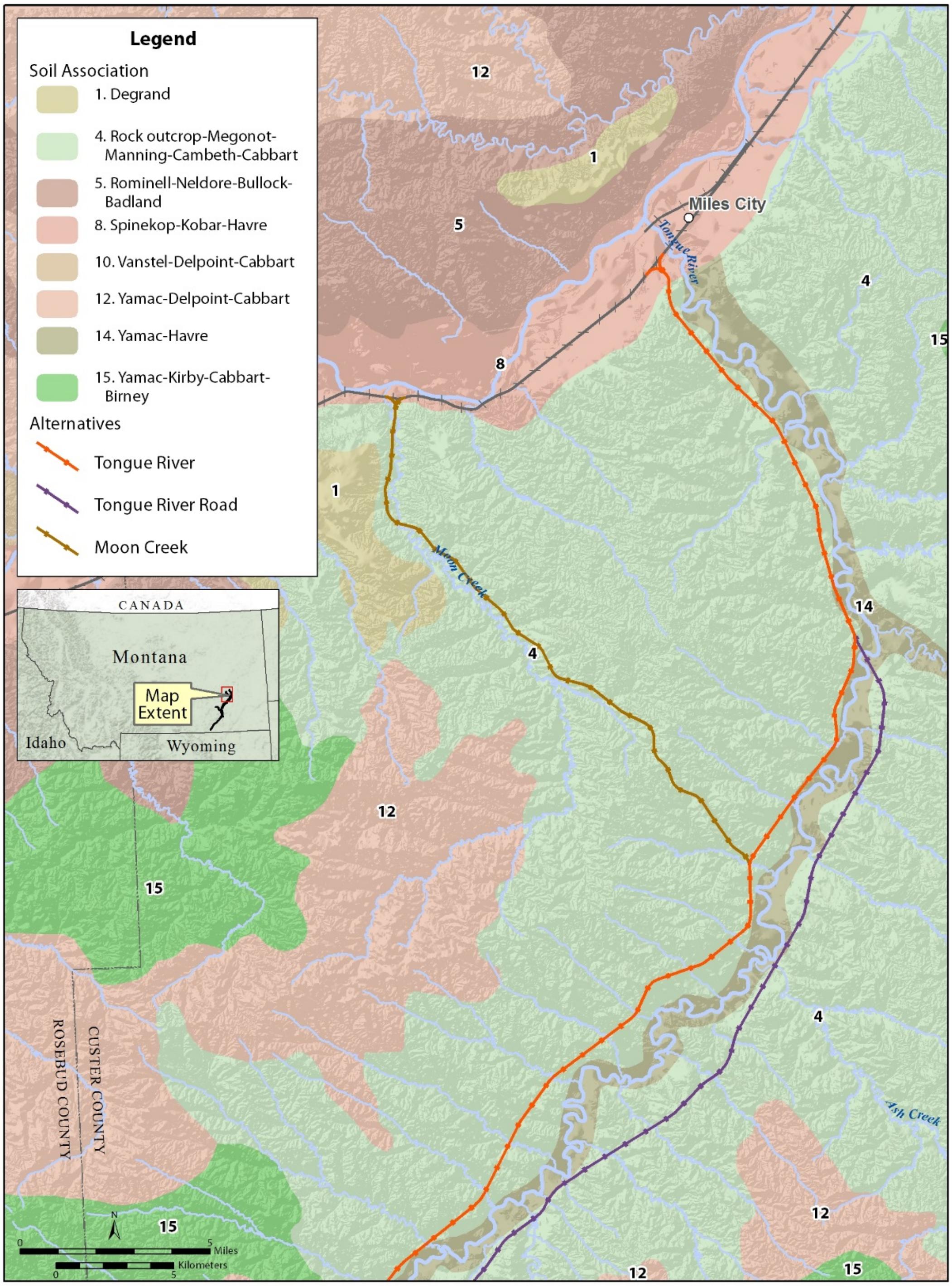


Figure 13.2-3a. Soil Associations within the Project Vicinity and Study Area

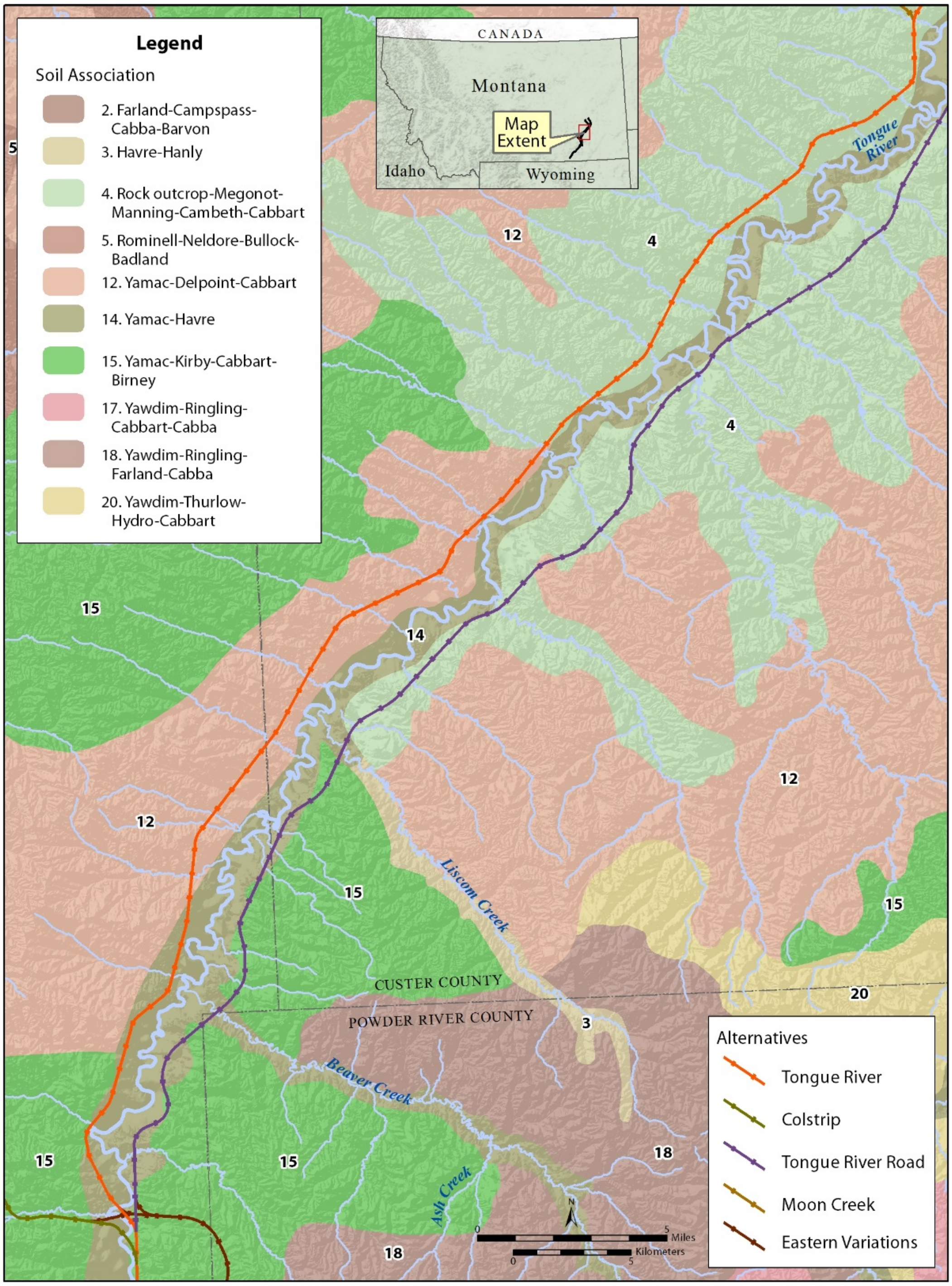


Figure 13.2-3b. Soil Associations within the Project Vicinity and Study Area

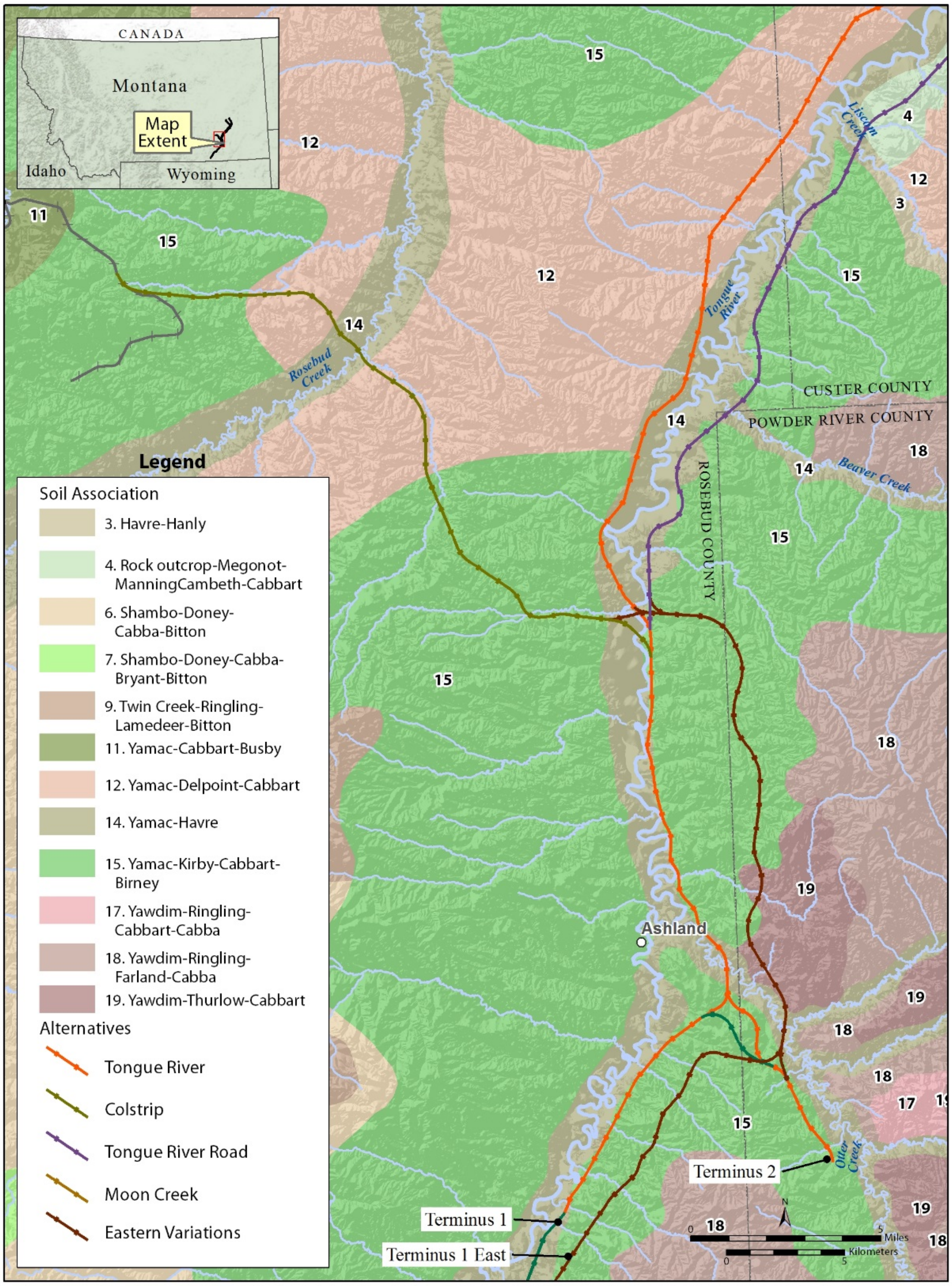


Figure 13.2-3c. Soil Associations within the Project Vicinity and Study Area

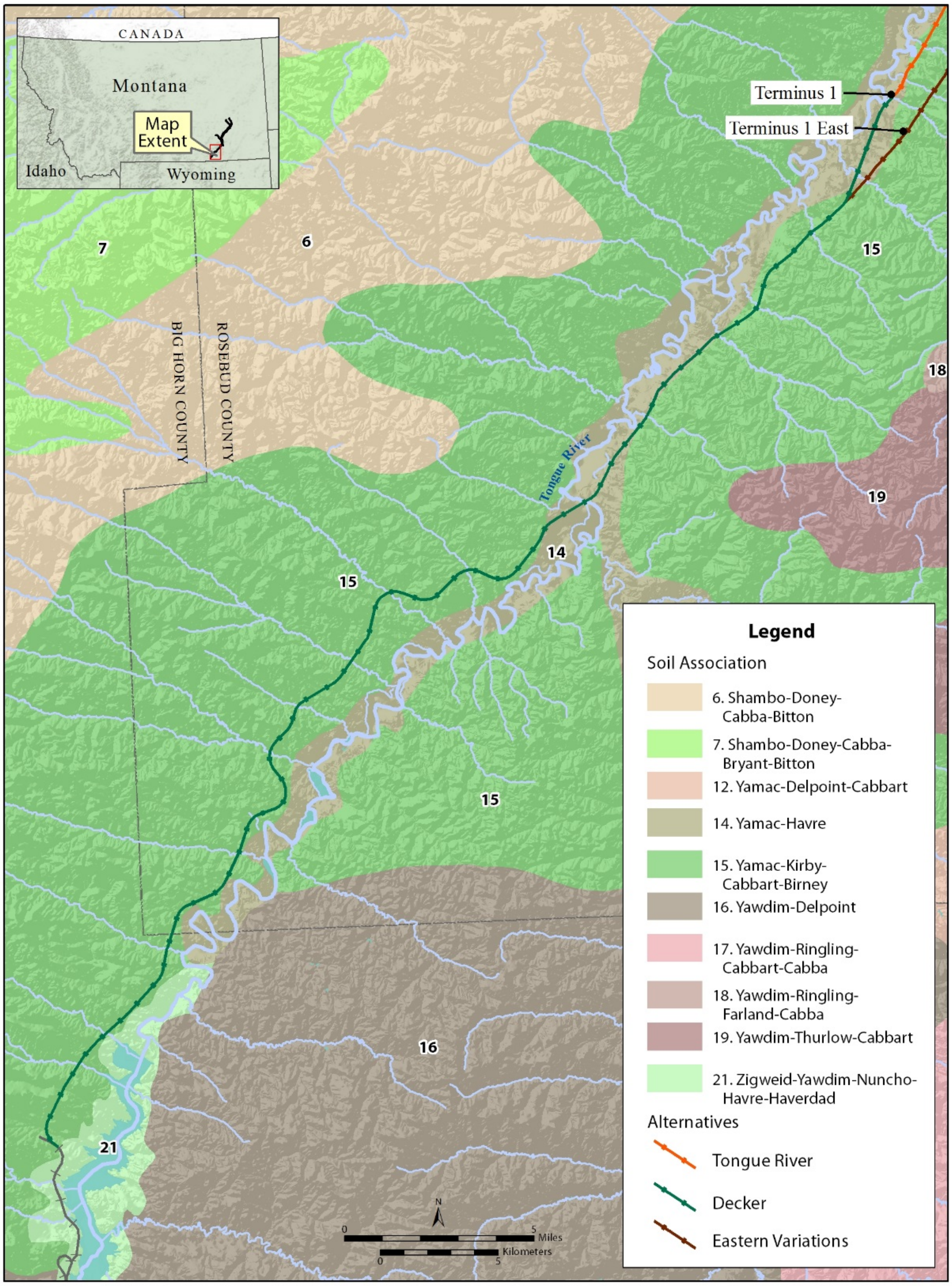


Figure 13.2-3d. Soil Associations within the Project Vicinity and Study Area

Rock Outcrop (Meganot-Manning-Cambeth-Cabbart)

These loamy soils are typically formed from sedimentary beds that occur on moderate to steep slopes. These soils generally occur on hills, ridges, and sedimentary plains, although the Manning series soils more often form from fluvial sediments overlying sand and gravel. Slopes in this association vary in gradient from 0 to 75 percent (Natural Resources Conservation Service 2014c).[2]

In the topography and soils study area, this soil association has an AASHTO classification of A-2, indicating that its significant constituent materials include silty or clayey gravel and sand and that it has a good rating as a subgrade. This soil association also has a low concrete corrosion rating and no hydric soils are present. Its linear extensibility is approximately 1.5 percent, indicating a low linear extensibility and therefore a low shrink-swell potential. The SAR for this soil association in the topography and soils study area is zero, indicating the absence of a sodic condition and therefore generally favorable conditions for soil permeability and aeration. The soil erodibility factor and slope gradient for this association are approximately 0.24 and 12 percent, respectively, suggesting a relatively low potential for erosion by water. Overall, this soil association has positive qualities for rail subgrade.

Spinekop-Kobar-Havre

These soils occur on nearly level to moderately sloping terrain. Havre soils are loamy and often occur on flood plains where they are subject to flooding. Spinekop soils are loamy and occur on stream terraces. Kobar soils are clayey and are generally found on alluvial fans and stream terraces (Natural Resource Conservation Service 2014c).

In the topography and soils study area, this soil association has an ASSHTO classification of A-4, indicating that its significant constituent materials include silty soils and that it has a fair rating as a subgrade. This soil association also has a low concrete corrosion rating and no hydric soils are present. Its linear extensibility is approximately 1.5 percent, indicating a low linear extensibility and therefore a low shrink-swell potential. The SAR for this soil association in the topography and soils study area is zero, indicating the absence of a sodic condition and therefore generally favorable conditions for soil permeability and aeration. The soil erodibility factor and slope gradient for this association are approximately 0.28 and 1 percent, respectively, suggesting a low potential for erosion by water. Overall, this soil association has positive qualities for rail subgrade.

Yamac-Delpoint-Cabbart

These soils occur mostly on gently sloping to very steep terrain and are well drained and loamy. Delpoint soils are generally present on gently sloping to moderately sloping terrain in sedimentary plains, and are moderately deep. They were formed in semiconsolidated, loamy sedimentary beds. Yamac soils occur on gentle to moderate slopes and are very deep; these

[2] This association description was compiled using information obtained from NRCS' online Official Soil Series Description tool.

soils form in alluvium and are typically present on alluvial fans and sedimentary plains. Cabbart soils occur on moderately steep to very steep terrain and are shallow. They form from semiconsolidated, loamy sedimentary beds and are on hills (Natural Resources Conservation Service 2014c).

In the topography and soils study area, this soil association has an ASSHTO classification of A-6, indicating that its significant constituent materials include clayey soils, resulting in a poor rating as a subgrade. This soil association also has a low concrete corrosion rating and no hydric soils are present. Its linear extensibility is approximately 4.5 percent, indicating moderate extensibility and therefore a moderate shrink-swell potential. The SAR for this soil association in the topography and soils study area is zero, indicating the absence of a sodic condition and therefore generally favorable conditions for soil permeability and aeration. The soil erodibility factor and slope gradient for this association are approximately 0.37 and 39 percent, respectively, indicating a moderate potential for erosion by water. Overall, this soil association has moderately poor qualities for rail subgrade.

Yamac-Havre

These soils are found on nearly level terrain and are loamy. Yamac soils generally occur on alluvial fans and stream terraces. Havre soils are present on floodplains and are subject to flooding (Natural Resources Conservation Service 2014c).

In the topography and soils study area, this soil association has an ASSHTO classification of A-6, indicating that its significant constituent materials include clayey soils, resulting in a poor rating as a subgrade. This soil association also has a low concrete corrosion rating and no hydric soils are present. Its linear extensibility is approximately 4.5 percent, indicating moderate extensibility and therefore a moderate shrink-swell potential. The SAR for this soil association in the topography and soils study area is zero, indicating the absence of a sodic condition and therefore generally favorable conditions for soil permeability and aeration. The soil erodibility factor and slope gradient for this association are approximately 0.32 and 1 percent, respectively, indicating a low potential for erosion by water. Overall, this soil association has fair to moderately poor qualities for rail subgrade.

Yamac-Kirby-Cabbart-Birney

These soils occur mostly on gently sloping to very steep terrain on alluvial fans and hills. The soils range from shallow to very deep and are well drained to excessively drained. The soils are loamy and clayey and formed in *colluvium*, *alluvium*, and material weathered from baked sandstone and shale, semiconsolidated loamy sedimentary beds, alluvium, and semiconsolidated shale (Natural Resource Conservation Service 2014a).

In the topography and soils study area, this soil association has an ASSHTO classification of A-6, indicating that its significant constituent materials are clayey soils, resulting in a poor rating as a subgrade. This soil association also has a low concrete corrosion rating and no hydric soils are present. Its linear extensibility is approximately 4.5 percent, indicating moderate extensibility and therefore a moderate shrink-swell potential. The SAR for this soil association in the topography and soils study area is three milliequivalents per liter, suggesting a fair balance of sodium to calcium and magnesium in the soil and generally favorable conditions for soil permeability and aeration. The soil erodibility factor and slope gradient for this association are approximately 0.37 and 9 percent, respectively, indicating a low potential for erosion by water. Overall, this soil association has fair to moderately poor qualities for rail subgrade.

Yawdim-Thurlow-Cabbart

These soils occur on gently to steeply sloping terrain and consist of well-drained loams, silt loams, clay loams, and silty clays. Yawdim soils occur on nearly level to very steep sedimentary upland hills and ridges and are generally shallow and clayey. Thurlow soils are typically very deep and well-drained soils that formed in *calcareous* clay loam unconsolidated materials. These soils are in valleys on river and stream terraces. Cabbart soils are well drained, loamy, and shallow. They formed in semiconsolidated, loamy sedimentary beds (Natural Resource Conservation Service 2014a).

In the topography and soils study area, this soil association does not have an ASSHTO classification. It has a low concrete corrosion rating and no hydric soils are present. Its linear extensibility is zero percent, indicating a negligible shrink-swell potential. The SAR for this soil association in the topography and soils study area is zero, indicating the absence of a sodic condition and therefore generally favorable conditions for soil permeability and aeration. The soil erodibility factor was not included in the NRCS STATSGO data and the slope gradient is approximately 27 percent. Considering the general soil association characteristics for drainage and the slope gradient in the topography and soils study area, this soil has a low potential for erosion by water. Overall, and based on available data, this soil association has positive qualities for rail subgrade.

Zigweid-Yawdim-Nuncho-Havre-Haverdad

These soils are generally characterized by very deep, well-drained soils, although Yawdim soils are shallow. They commonly occur on alluvial fans, floodplains, low terraces, and, in the case of Zigweid and Yawdim soils, on ridges and hills. With the exception of Yawdim soils, they generally occur on slopes ranging in gradient from 0 to 20 percent; Yawdim soils can occur on slopes up to 70 percent (Natural Resource Conservation Service 2014a).

In the topography and soils study area, this soil association has an ASSHTO classification of A-6. Its significant constituent materials include clayey soils, resulting in a poor rating as a subgrade. This soil association also has a low concrete corrosion rating and no hydric soils are present. Its linear extensibility is approximately 4.5 percent, indicating moderate extensibility and therefore a moderate shrink-swell potential. The SAR for this soil association in the topography and soils study area is zero, indicating the absence of a sodic condition and therefore generally favorable conditions for soil permeability and aeration.

The soil erodibility factor and slope gradient for this association are approximately 0.37 and 8 percent, respectively, indicating a low potential for erosion by water. Overall, this soil association has fair to moderately poor qualities for rail subgrade.

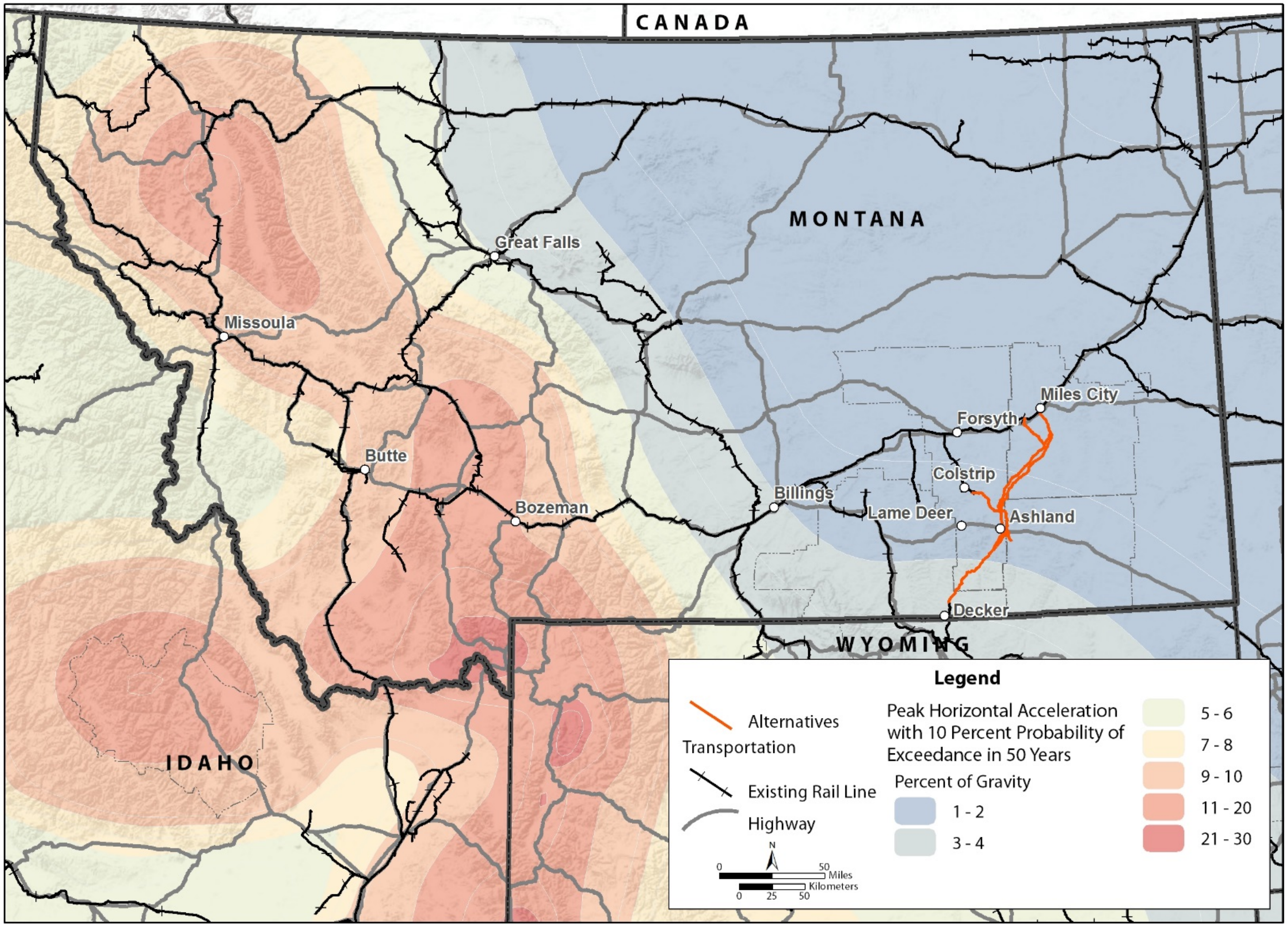
13.2.3.4 Seismic Hazards

The Great Falls Tectonic Zone is a major intracontinental *shear zone* that crosses western Montana. The zone is approximately 100 miles wide and extends from the southwestern Idaho/Montana border across Montana to the northwest Montana/Saskatchewan/North Dakota border. Additionally, a belt of seismicity is located in western Montana and includes the Northern Rocky Mountains, Northern Intermountain Seismic Belt, Centennial Tectonic Belt, and Yellowstone seismic zones. This belt extends from the northwest corner of the state to the Yellowstone National Park region where the borders of Montana, Idaho, and Wyoming meet. This region of Montana is known to be seismically active and has been the site of the two largest historic earthquakes in the region; the August 18, 1959 Hebgen Lake, Montana quake (M 7.5) and the October 28, 1983 Borah Peak, Idaho quake (M 7.3) (Montana Bureau of Mines and Geology 2014, Montana Department of Natural Resources and Conservation and Federal Emergency Management Agency 2005).

The proposed rail line would be located in the eastern portion of the Northern Great Plain seismic zone. According to historical seismicity and quaternary faulting maps (maps that show surface faults known to be active in the last 1.6 million years), one quaternary fault is located in the northeastern corner of the state. This region is considered to be of relatively low seismic activity. Historical seismicity mapping indicates that the average earthquake magnitude is between 1.5 and 5.0. Additionally, probabilistic earthquake ground-shaking maps indicate that the level of *peak horizontal acceleration* (ground shaking) has a 10 percent probability of exceeding 0.1 to 0.2 (g) in 50 years. This indicates that the Northern Great Plain seismic zone experiences weak to moderate ground shaking and light damage (Montana Department of Natural Resources and Conservation and Federal Emergency Management Agency 2005). The difference between earthquake magnitude and shaking is that magnitude is a measurement of the size of the quake (typically related to the amount of energy released), whereas earthquake shaking is a measure of an earthquake's acceleration, which is one of the primary causes of damage. In the geologic study area, there is a 10 percent chance of ground shaking greater than 0.2 g in 50 years. Figure 13.2-4 shows the seismic hazard zones for the state of Montana.

13.2.4 Environmental Consequences

Impacts on geology and soils could result from construction and operation of the build alternatives. The impacts common to all build alternatives are presented first, followed by impacts specific to the build alternatives.



This project area is located in an area with 10 percent chance of experiencing ground-shaking greater than 2% gravity in 50 years. This indicates that there is a low probability to experience substantial ground shaking in the vicinity of the project.

Figure 13.2-4. Seismic Hazard Map for Montana

13.2.4.1 Impacts Common to All Build Alternatives

Construction

The following construction impacts are common to all build alternatives.

- **Alter the Existing Topography**

  Most of the build alternatives would cross terrain with a grade of greater than 1 percent and would require extensive cut and fill to meet ruling grade requirements. This would result in substantial permanent physical impacts on the existing topography. Section 13.2.4.2, *Impacts by Build Alternative*, quantifies impacts related to soil suitability, slumping, and slope failure.

  Temporary construction impacts would include cuts needed for access or for temporary facilities such as construction staging areas, material laydown/stockpile areas, and emergency facilities. Visual impacts would occur.

  Permanent construction impacts would occur wherever the terrain is cut and/or filled to meet rail line design objectives. Steeper terrain would require more cut and fill than flatter terrain. Build alternatives traversing steep terrain would have greater impacts on topography.

- **Alter Geologic Formations Unsuitable for Construction (Bedrock)**

  Most build alternatives would cross the three distinct members of the Fort Union Formation (Section 13.2.3.2, *Geology, Fort Union Formation*) and could encounter bedrock at varying depths and locations during rail line construction. No build alternative would encounter bedrock in areas where it would cross Quaternary alluvium and/or terrace deposits.

  During construction of any build alternative, it could be necessary to remove bedrock to maintain grade and a suitable foundation. Excavation of bedrock can be difficult with conventional machinery and blasting could be required if conventional machinery is not adequate. These geologic units are typical in this area of Montana and contractors are familiar with methods to handle excavations in the Fort Union Formation.

  The exact location of exposed and shallow bedrock can only be ascertained from detailed geologic and engineering studies, which would occur if a build alternative is approved. Impacts on geologic formations, such as slope stability and drainage, are discussed for soils in Section 13.2.4.2, *Impacts by Build Alternative*.

- **Alter Soils Unsuitable For Construction (Unstable Conditions, Soil Slumping, Slope Failure, and Hydric and Sodic Soils)**

  Construction activities for all build alternatives could encounter soils with fair to poor suitability for rail line construction. These soils would need to be removed and replaced with fill extracted from other areas within the right-of-way. At some locations, a build alternative could encounter hills or slopes that would need to be cut to ensure a safe and feasible grade for rail operation. These cuts could potentially affect the stability of the slope. Generally, larger slope cuts would result in a greater potential for erosion.

The exact nature of the soils in a right-of-way and the determination of their potential to slump, fail, or otherwise be unsuitable for construction, can only be ascertained from detailed geologic and engineering studies. These studies would take place once a build alternative is approved. In areas with a potential for slumping, the design could include, as appropriate, engineering controls such as flattened slopes, adequate drainage, retaining structures, geotechnically designed stabilization techniques, terracing and controls for surface water runoff.

- **Loss Through Erosion**

  With the exception of the Decker Alternative, all of the build alternatives would cross the Yamac-Delpoint-Cabbart soil association. This association has a moderate soil erodibility factor and occurs on a slope of approximately 39 percent. All build alternatives would also cross other soil associations not considered susceptible to high rates of erosion by water. Accelerated soil erosion could occur where hills or slopes are cut in erodible soils and if exposed soils are not protected from erosion, such as in areas cleared of vegetation and stockpiles of excavation materials. Topsoil could erode and cause indirect impacts on water quality and loss of prime farmland and farmland of statewide importance. Construction methods that require more ground exposure would incur greater risks from water and wind erosion. Some construction components, such as elevated structures on deep foundations, would have limited potential for accelerated erosion because exposed earth would be limited. Other components, such as at-grade segments, could have greater potential for erosion. Both the retained cut and retained fill would have less erosion risk because of the area of exposed earth would be limited.

Operation

The following operation impacts are common to all build alternatives. The magnitude of the impact would vary depending on the volume of rail traffic and required maintenance.

- **Operate in an Area of Seismic Hazards**

  Although none of the build alternatives would traverse any known active or potentially active faults, the geologic study area could experience weak to moderate ground shaking in a seismic event. This could potentially lead to a train derailment. Historical seismicity mapping in the geologic study area indicates that the average earthquake magnitude is between 1.5 and 5.0 (Montana Department of Natural Resources and Conservation and Federal Emergency Management Agency 2005). A large seismic event could potentially affect the alignment or damage the tracks, railbed, or access roads.

13.2.4.2 Impacts by Build Alternative

The impacts related to geology and soils that are specific to each build alternative are described below, and are represented in the following tables and figures.

- Table 13.2-3 summarizes the slope analysis by build alternative.
- Table 13.2-4 summarizes the average amount of soil that would be moved per mile of right-of-way, by build alternative.
- Table 13.2-5 identifies the geologic formations that each build alternative would traverse.
- Table 13.2-6 summarizes the soil associations and their geochemical properties by build alternative.

Table 13.2-3. Slope Analysis of Build Alternatives

Build Alternative	≤1% (miles)	≤ 1% (% of total miles)	> 1% but ≤ 5% (miles)	> 1% but ≤5% (% of total miles)	> 5% (miles)	> 5% (% of total miles)	Total (miles)
Tongue River	17.79	21	35.35	42	30.57	37	83.71
Tongue River East	17.36	20	36.07	42	32.88	38	86.31
Colstrip	9.40	22	17.46	41	15.45	37	42.31
Colstrip East	8.75	19	18.69	41	18.00	40	45.43
Tongue River Road	19.91	24	34.26	41	29.50	35	83.66
Tongue River Road East	19.11	22	34.91	41	31.89	37	85.92
Moon Creek	15.06	18	37.98	46	29.11	35	82.15
Moon Creek East	14.60	17	38.68	46	31.41	37	84.69
Decker	6.27	12	19.52	38	25.30	50	51.09
Decker East	5.91	12	18.83	38	24.88	50	49.63

Table 13.2-4. Cut and Fill Requirements by Build Alternative

Build Alternative	Cut (MCY)	Fill (MCY)	Total Earth Moved (MCY)	Length of Alternative (miles)	Average Earth Moved per Mile (MCY/mile)
Tongue River	25.30	22.90	48.20	83.71	0.58
Tongue River East	41.59	37.41	79.00	86.31	0.92
Colstrip	18.20	16.37	34.57	42.31	0.82
Colstrip East	34.48	30.88	65.36	45.43	1.44
Tongue River Road	38.80	34.60	73.40	83.66	0.88
Tongue River Road East	55.09	49.11	104.2	85.92	1.21
Moon Creek	36.20	33.10	69.30	82.15	0.84
Moon Creek East	52.49	47.61	100.1	84.69	1.18
Decker	42.77	39.71	82.48	51.09	1.61
Decker East	49.76	45.75	95.51	49.63	1.92

Notes:
MCY = million cubic yards

Table 13.2-5. Geologic Formations in the Geologic Study Area

Alternative	Total Acres	Qal (acres)	Qal (%)[a]	Qat (acres)	Qat (%)[a]	Tfle (acres)	Tfle (%)[a]	Tft (acres)	Tft (%)[a]	Tftr (acres)	Tftr (%)[a]
Tongue River	3,783	450	12	242	6	498	13	1,283	34	1,311	35
Tongue River East	3,803	257	7	251	6	498	13	1,283	34	1,515	40
Colstrip	2,040	419	21	-	-	-	-	-	-	1,621	79
Colstrip East	2,094	207	10	36	2	-	-	-	-	1,850	88
Tongue River Road	4,234	470	11	313	7	1,002	24	1,153	27	1,296	31
Tongue River Road East	4,218	274	7	292	7	1,002	24	1,153	27	1,497	35
Moon Creek	4,026	486	12	96	2	797	20	1,336	33	1,311	33
Moon Creek East	4,047	293	7	105	3	797	20	1,336	33	1,515	37
Decker	2,826	444	16	35	1	-	-	-	-	2,348	83
Decker East	2,695	359	13	35	1	-	-	-	-	2,301	86

Notes:
[a] Rounding error may result in a total slightly different than 100%
Qal = Quaternary Alluvium; Qat = Quaternary Alluvium Terrace Deposit; Tfle = Lebo Member of Fort Union Formation; Tft = Tullock Member of Fort Union Formation; Tftr = Tongue River Member of Fort Union Formation

Table 13.2-6. Soil Associations by Build Alternative

Alternative	Identified Soil Associations	Acreage	Acreage (%)	ASSHTO Classification	Concrete Corrosion Rating	Hydric Soil Rating (y/n)	Linear Extensibility	Sodium Absorption Ratio	Soil Erodibility Factor	Slope (%)	Suitability for Construction
				Physical Properties of Soil Associations							
Tongue River	Rock outcrop-Megonot-Manning-Cambeth-Cabbart (A-2)	1,215	32	A-2	Low	No	1.5	0	0.24	12	Excellent
	Spinekop-Kobar-Havre (A-4)	26	1	A-4	Low	No	1.5	0	0.28	1	Good
	Yamac-Delpoint-Cabbart (A-6)	722	19	A-6	Low	No	4.5	0	0.37	39	Moderately Poor
	Yamac-Havre (A-6)	741	20	A-6	Low	No	4.5	0	0.32	1	Fair – Moderately Poor
	Yamac-Kirby-Cabbart-Birney (A-6)	1,078	29	A-6	Low	No	4.5	3	0.37	9	Fair – Moderately Poor
Tongue River East	Rock outcrop-Megonot-Manning-Cambeth-Cabbart (A-2)	1,215	32	A-2	Low	No	1.5	0	0.24	12	Excellent
	Spinekop-Kobar-Havre (A-4)	26	1	A-4	Low	No	1.5	0	0.28	1	Good
	Yamac-Delpoint-Cabbart (A-6)	722	19	A-6	Low	No	4.5	0	0.37	39	Moderately Poor
	Yamac-Havre (A-6)	631	17	A-6	Low	No	4.5	0	0.32	1	Fair – Moderately Poor
	Yamac-Kirby-Cabbart-Birney (A-6)	1,057	28	A-6	Low	No	4.5	3	0.37	9	Fair – Moderately Poor
	Yawdim-Thurlow-Cabbart (NA)	152	4	-	Low	No	0	0	-	27	Good
Colstrip	Yamac-Delpoint-Cabbart (A-6)	231	11	A-6	Low	No	4.5	0	0.37	39	Moderately Poor
	Yamac-Havre(A-6)	306	15	A-6	Low	No	4.5	0	0.32	1	Fair – Moderately Poor
	Yamac-Kirby-Cabbart-Birney (A-6)	1,502	74	A-6	Low	No	4.5	3	0.37	9	Fair – Moderately Poor

Alternative	Identified Soil Associations	Acreage	Acreage (%)	Physical Properties of Soil Associations: ASSHTO Classification	Concrete Corrosion Rating	Hydric Soil Rating (y/n)	Linear Extensibility	Sodium Absorption Ratio	Soil Erodibility Factor	Slope (%)	Suitability for Construction
Colstrip East	Yamac-Delpoint-Cabbart (A-6)	231	11	A-6	Low	No	4.5	0	0.37	39	Moderately Poor
	Yamac-Havre (A-6)	206	10	A-6	Low	No	4.5	0	0.32	1	Fair – Moderately Poor
	Yamac-Kirby-Cabbart-Birney (A-6)	1,504	72	A-6	Low	No	4.5	3	0.37	9	Fair – Moderately Poor
	Yawdim-Thurlow-Cabbart (NA)	152	7	-	Low	No	0	0	-	27	Good
Tongue River Road	Rock outcrop-Megonot-Manning-Cambeth-Cabbart (A-2)	1,913	45	A-2	Low	No	1.5	0	0.24	12	Excellent
	Spinekop-Kobar-Havre (A-4)	26	1	A-4	Low	No	1.5	0	0.28	1	Good
	Yamac-Delpoint-Cabbart (A-6)	35	1	A-6	Low	No	4.5	0	0.37	39	Moderately Poor
	Yamac-Havre (A-6)	838	20	A-6	Low	No	4.5	0	0.32	1	Fair – Moderately Poor
	Yamac-Kirby-Cabbart-Birney (A-6)	1,423	34	A-6	Low	No	4.5	3	0.37	9	Fair – Moderately Poor
Tongue River Road East	Rock outcrop-Megonot-Manning-Cambeth-Cabbart (A-2)	1,913	45	A-2	Low	No	1.5	0	0.24	12	Excellent
	Spinekop-Kobar-Havre (A-4)	26	1	A-4	Low	No	1.5	0	0.28	1	Good
	Yamac-Delpoint-Cabbart (A-6)	35	1	A-6	Low	No	4.5	0	0.37	39	Moderately Poor
	Yamac-Havre (A-6)	717	17	A-6	Low	No	4.5	0	0.32	1	Fair – Moderately Poor
	Yamac-Kirby-Cabbart-Birney (A-6)	1,376	33	A-6	Low	No	4.5	3	0.37	9	Fair – Moderately Poor
	Yawdim-Thurlow-Cabbart (NA)	152	4	-	Low	No	0	0	-	27	Good

Alternative	Identified Soil Associations	Acreage	Acreage (%)	ASSHTO Classification	Concrete Corrosion Rating	Hydric Soil Rating (y/n)	Linear Extensibility	Sodium Absorption Ratio	Soil Erodibility Factor	Slope (%)	Suitability for Construction
Moon Creek	Rock outcrop-Megonot-Manning-Cambeth-Cabbart (A-2)	1,608	40	A-2	Low	No	1.5	0	0.24	12	Excellent
	Spinekop-Kobar-Havre (A-4)	17	< 1	A-4	Low	No	1.5	0	0.28	1	Good
	Yamac-Delpoint-Cabbart (A-6)	722	18	A-6	Low	No	4.5	0	0.37	39	Moderately Poor
	Yamac-Havre (A-6)	600	15	A-6	Low	No	4.5	0	0.32	1	Fair – Moderately Poor
	Yamac-Kirby-Cabbart-Birney (A-6)	1,078	27	A-6	Low	No	4.5	3	0.37	9	Fair – Moderately Poor
Moon Creek East	Rock outcrop-Megonot-Manning-Cambeth-Cabbart (A-2)	1,608	40	A-2	Low	No	1.5	0	0.24	12	Excellent
	Spinekop-Kobar-Havre (A-4)	17	< 1	A-4	Low	No	1.5	0	0.28	1	Good
	Yamac-Delpoint-Cabbart (A-6)	722	18	A-6	Low	No	4.5	0	0.37	39	Moderately Poor
	Yamac-Havre (A-6)	490	12	A-6	Low	No	4.5	0	0.32	1	Fair – Moderately Poor
	Yamac-Kirby-Cabbart-Birney (A-6)	1,057	26	A-6	Low	No	4.5	3	0.37	9	Fair – Moderately Poor
	Yawdim-Thurlow-Cabbart (NA)	152	4	-	Low	No	0	0	-	27	Good

Alternative	Identified Soil Associations	Acreage	Acreage (%)	Physical Properties of Soil Associations: ASSHTO Classification	Concrete Corrosion Rating	Hydric Soil Rating (y/n)	Linear Extensibility	Sodium Absorption Ratio	Soil Erodibility Factor	Slope (%)	Suitability for Construction
Decker	Yamac-Havre (A-6)	417	15	A-6	Low	No	4.5	0	0.32	1	Fair – Moderately Poor
	Yamac-Kirby-Cabbart-Birney (A-6)	2,409	85	A-6	Low	No	4.5	3	0.37	9	Fair – Moderately Poor
	Zigweid-Yawdim-Nuncho-Havre-Haverdad (A-6)	< 1	< 1	A-6	Low	No	4.5	0	0.37	8	Fair – Moderately Poor
Decker East	Yamac-Havre (A-6)	288	11	A-6	Low	No	4.5	0	0.32	1	Fair – Moderately Poor
	Yamac-Kirby-Cabbart-Birney (A-6)	2,407	89	A-6	Low	No	4.5	3	0.37	9	Fair – Moderately Poor
	Zigweid-Yawdim-Nuncho-Havre-Haverdad (A-6)	< 1	< 1	A-6	Low	No	4.5	0	0.37	8	Fair – Moderately Poor

Notes:
Source: Natural Resource Conservation Service n.d.

Tongue River Alternatives

Tongue River Alternative

Topography

The Tongue River Alternative would be 83.71 miles long. Of this length, 17.79 miles (21 percent) would cross terrain with a slope less than or equal to 1 percent, 35.35 miles (42 percent) would cross terrain with a slope greater than 1 percent and less than or equal to 5 percent, and 30.57 miles (37 percent) would cross terrain with a slope greater than 5 percent (Table 13.2-3).

The Tongue River Alternative would require 25.30 and 22.90 MCY of cut and fill, respectively, for a total of 48.20 MCY of earth moved or 0.58 MCY of earth moved per mile (Table 13.2-4). This build alternative would require substantial amounts of cut and fill, which would result in permanent physical impacts on the existing topography.

Geology

The total length of the Tongue River Alternative would be 83.71 miles and the right-of-way would encompass 3,783 acres. Approximately 450 acres (12 percent) and 242 acres (6 percent) of this build alternative would cross Quaternary alluvium and terrace deposits, respectively. Approximately 498 (13 percent), 1,283 acres (34 percent), and 1,311 acres (35 percent) of this build alternative would cross the Lebo, Tullock, and the Tongue River Members of the Fort Union Formation, respectively (Table 13.2-5). Although this build alternative would not encounter bedrock when crossing Quaternary alluvium and/or terrace deposits, it could encounter bedrock at varying depths and locations in any of the three distinct members of the Fort Union Formation.

Soils

The Tongue River Alternative would be constructed on excellent to moderately poor soils unsuitable for rail line construction. Approximately 32 percent of the right-of-way would cross the Rock outcrop-Megonot-Manning-Cambeth-Cabbart association, which has excellent qualities for rail subgrade. This build alternative would also cross soils with the following suitability for construction: good (1 percent), moderately poor (19 percent), and fair to moderately poor (49 percent) (Table 13.2-6). Soils with fair to poor suitability for rail line construction would need to be removed and replaced with fill extracted from other areas within the right-of-way.

Due to the topography of the topography and soils study area, 79 percent of the Tongue River Alternative would encounter hills or slopes greater than 1 percent that would need to be cut to ensure a safe and feasible grade for rail operation. These cuts could affect the stability of the slope. Generally, larger slope cuts would result in a greater potential for erosion.

Tongue River East Alternative

Topography

The Tongue River East Alternative would be 86.31 miles long. Of this length, 17.36 miles (20 percent) would cross terrain with a slope less than or equal to 1 percent, 36.07 miles (42 percent) would cross terrain with a slope greater than 1 percent and less than or equal to 5 percent, and 32.88 miles (38 percent) would cross terrain with a slope greater than 5 percent (Table 13.2-3).

The Tongue River East Alternative would require 41.59 and 37.41 MCY of cut and fill, respectively, for a total of 79.00 MCY of earth moved or 0.92 MCY of earth moved per mile (Table 13.2-4). This build alternative would require substantial amounts of cut and fill, which would result in permanent physical impacts on the existing topography.

Geology

The total length of the Tongue River East Alternative would be 86.31 miles and the right-of-way would encompass 3,803 acres. Approximately 257 acres (7 percent) and 251 acres (6 percent) of this build alternative would cross Quaternary alluvium and terrace deposits, respectively. Approximately 498 (13 percent), 1,283 acres (34 percent), and 1,515 acres (40 percent) of this build alternative would cross the Lebo, Tullock, and Tongue River Members of the Fort Union Formation, respectively (Table 13.2-5). The risk of this build alternative crossing bedrock would be the same as the risk described for the Tongue River Alternative.

Soils

The Tongue River East Alternative would be constructed on soils with excellent qualities for rail subgrade, as well as soils with good, fair to moderately poor, and moderately poor qualities. Approximately 32 percent of the right-of-way would cross the Rock outcrop-Megonot-Manning-Cambeth-Cabbart association, which has excellent qualities for rail subgrade. The build alternative would also cross soils with the following suitability for construction: good (5 percent), fair to moderately poor (45 percent), and moderately poor (19 percent) (Table 13.2-6). The risk of exposure of this build alternative to soils unsuitable for construction would be the same as the risk described for the Tongue River Alternative.

Colstrip Alternatives

Colstrip Alternative

Topography

The Colstrip Alternative would be 42.31 miles long. Of this length, 9.4 miles (22 percent) would cross terrain with a slope less than or equal to 1 percent, 17.46 miles (41 percent) would cross terrain with a slope greater than 1 percent and less than or equal to 5 percent, and 15.45 miles (37 percent) would cross terrain with a slope greater than 5 percent (Table 13.2-3).

The Colstrip Alternative would require 18.20 and 16.37 MCY of cut and fill, respectively, for a total of 34.57 MCY of earth moved or 0.82 MCY of earth moved per mile (Table 13.2-4). This build alternative would result in permanent physical impacts on the existing topography.

Geology

The total length of the Colstrip Alternative would be 42.31 miles and the right-of-way would encompass 2,040 acres. Approximately 419 acres (21 percent) of this build alternative would cross Quaternary alluvium (Table 13.2-5). No terrace deposits would be encountered by this build alternative. Approximately 1,621 acres (79 percent) of this alternative would cross the Tongue River Member of the Fort Union Formation. The risk of this build alternative crossing bedrock would be the same as the risk described for the Tongue River Alternative.

Soils

The Colstrip Alternative would encounter fair to moderately poor soils unsuitable for rail line construction. The build alternative would cross soils with the following suitability for construction: fair to moderately poor (89 percent) and moderately poor (11 percent) (Table 13.2-6). The Colstrip Alternative would not encounter hydric and sodic soils and the potential for soil and topsoil erosion is expected to be low, except for segment that crosses the Yamac-Delpoint-Cabbart soil association.

Colstrip East Alternative

Topography

The Colstrip East Alternative would be 45.43 miles long. Of this length, 8.75 miles (19 percent) would cross terrain with a slope less than or equal to 1 percent, 18.69 miles (41 percent) would cross terrain with a slope greater than 1 percent and less than or equal to 5 percent, and 18.00 miles (40 percent) would cross terrain with a slope greater than 5 percent (Table 13.2-3).

The Colstrip East Alternative would require 34.48 and 30.88 MCY of cut and fill, respectively, for a total of 65.36 MCY of earth moved or 1.44 MCY of earth moved per mile (Table 13.2-4). This build alternative would require significant amounts of cut and fill, which would result in permanent physical impacts on the existing topography.

Geology

The total length of the Colstrip East Alternative would be 45.43 miles and the right-of-way would encompass 2,094 acres. Approximately 207 acres (10 percent) and 36 acres (2 percent) of this alternative would cross Quaternary alluvium and terrace deposits, respectively (Table 13.2-5). Approximately 1,850 acres (88 percent) would cross the Tongue River Member of the Fort Union Formation. The risk of this build alternative crossing bedrock would be the same as the risk described for the Tongue River Alternative.

Soils

The Colstrip East Alternative would encounter good to moderately poor soils unsuitable for rail line construction. The build alternative would cross soils with the following suitability for construction: good (7 percent), fair to moderately poor (82 percent), and moderately poor (11 percent) (Table 13.2-6).

Tongue River Road Alternatives

Tongue River Road Alternative

Topography

The Tongue River Road Alternative would be 83.66 miles long. Of this length, 19.91 miles (24 percent) would cross terrain with a slope less than or equal to 1 percent, 34.26 miles (41 percent) would cross terrain with a slope greater than 1 percent and less than or equal to 5 percent, and 29.50 miles (35 percent) would cross terrain with a slope greater than 5 percent (Table 13.2-3).

The Tongue River Road Alternative would require 38.80 and 34.60 MCY of cut and fill, respectively, for a total of 73.40 MCY of earth moved or 0.88 MCY of earth moved per mile (Table 13.2-4). This build alternative would require substantial amounts of cut and fill, which would result in permanent physical impacts on the existing topography.

Geology

The total length of the Tongue River Road Alternative would be 83.66 miles and the right-of-way would encompass 4,234 acres. Approximately 470 acres (11 percent) and 313 acres (7 percent) of this build alternative would cross Quaternary alluvium and terrace deposits, respectively. Approximately 1,002 acres (24 percent), 1,153 acres (27 percent), and 1,296 acres (31 percent) of this build alternative would cross the Lebo, Tullock, and Tongue River Members of the Fort Union Formation, respectively (Table 13.2-5). The risk of this build alternative crossing bedrock would be the same as the risk described for the Tongue River Alternative.

Soils

The Tongue River Road Alternative would encounter excellent to moderately poor soils unsuitable for rail line construction. Approximately 45 percent of the right-of-way would cross the Rock outcrop-Megonot-Manning-Cambeth-Cabbart association, which has excellent qualities for rail subgrade. The build alternative would also cross soils with the following suitability for construction: good (1 percent), fair to moderately poor (54 percent) and moderately poor (1 percent) (Table 13.2-6).

Tongue River Road East Alternative

Topography

The Tongue River Road East Alternative would be 85.92 miles long. Of this length, 19.11 miles (22 percent) would cross terrain with a slope less than or equal to 1 percent, 34.91 miles (41 percent) would cross terrain with a slope greater than 1 percent and less than or equal to 5 percent, and 31.89 miles (37 percent) would cross terrain with a slope greater than 5 percent (Table 13.2-3).

The Tongue River Road East Alternative would require 55.09 and 49.11 MCY of cut and fill, respectively, for a total of 104.2 MCY of earth moved or 1.21 MCY of earth moved per mile (Table 13.2-4). This build alternative would require substantial amounts of cut and fill, which would result in permanent physical impacts on the existing topography.

Geology

The total length of the Tongue River Road East Alternative would be 85.92 miles and the right-of-way would encompass 4,218 acres. Approximately 274 acres (7 percent) and 292 acres (7 percent) of this build alternative would cross Quaternary alluvium and terrace deposits, respectively. Approximately 1,002 acres (24 percent), 1,153 acres (27 percent), and 1,497 acres (35 percent) of this build alternative would cross the Lebo, Tullock, and Tongue River Members of the Fort Union Formation, respectively (Table 13.2-5). The risk of this build alternative crossing bedrock would be the same as the risk described for the Tongue River Alternative.

Soils

The Tongue River Road East Alternative would be constructed on excellent to moderately poor soils unsuitable for rail line construction. Approximately 45 percent of the right-of-way would cross the Rock outcrop-Megonot-Manning-Cambeth-Cabbart association, which has excellent qualities for rail subgrade. The build alternative would also cross soils with the following suitability for construction: good (5 percent), fair to moderately poor (50 percent), and moderately poor (1 percent) (Table 13.2-6).

Moon Creek Alternatives

Moon Creek Alternative

Topography

The Moon Creek Alternative would be 82.15 miles long. Of this length, 15.06 miles (18 percent) would cross terrain with a slope less than or equal to 1 percent, 37.98 miles

(46 percent) would cross terrain with a slope greater than 1 percent and less than or equal to 5 percent, and 29.11 miles (35 percent) would cross terrain with a slope greater than 5 percent (Table 13.2-3).

The Moon Creek Alternative would require 36.20 and 33.10 MCY of cut and fill, respectively, for a total of 69.30 MCY of earth moved or 0.84 MCY of earth moved per mile (Table 13.2-4). This build alternative would require substantial amounts of cut and fill, which would result in permanent physical impacts on the existing topography.

Geology

The total length of the Moon Creek Alternative would be 82.15 miles and the right-of-way would encompass 4,026 acres. Approximately 486 acres (12 percent) and 96 acres (2 percent) of this build alternative would cross Quaternary alluvium and terrace deposits, respectively. Approximately 797 acres (20 percent), 1,336 acres (33 percent), and 1,311 acres (33 percent) of this build alternative would cross the Lebo, Tullock, and Tongue River Members of the Fort Union Formation, respectively (Table 13.2-5). The risk of this build alternative crossing bedrock would be the same as the risk described for the Tongue River Alternative.

Soils

The Moon Creek Alternative would be constructed on excellent to moderately poor soils. Approximately 40 percent of the right-of-way would cross the Rock outcrop-Megonot-Manning-Cambeth-Cabbart association, which has excellent qualities for rail subgrade. The build alternative would also cross soils with the following suitability for construction: good (less than 1 percent) and fair to moderately poor (42 percent), and moderately poor (18 percent) (Table 13.2-6). Hydric and sodic soils are not present and the potential for topsoil erosion is expected to be low except for the segment that crosses the Yamac-Delpoint-Cabbart soil association.

Moon Creek East Alternative

Topography

The Moon Creek East Alternative would be 84.69 miles long. Of this length, 14.60 miles (17 percent) would cross terrain with a slope less than or equal to 1 percent, 38.68 miles (46 percent) would cross terrain with a slope greater than 1 percent and less than or equal to 5 percent, and 31.41 miles (37 percent) would cross terrain with a slope greater than 5 percent (Table 13.2-3).

The Moon Creek East Alternative would require 52.49 and 47.61 MCY of cut and fill, respectively, for a total of 100.1 MCY of earth moved or 1.18 MCY of earth moved per mile (Table 13-4). This build alternative would require substantial amounts of cut and fill, which would result in permanent physical impacts on the existing topography.

Geology

The total length of the Moon Creek East Alternative would be 84.69 miles and the right-of-way would encompass 4,047 acres. Approximately 293 acres (7 percent) and 105 acres (3 percent) of this build alternative would cross Quaternary alluvium and terrace deposits, respectively. Approximately 797 acres (20 percent), 1,336 acres (33 percent), and 1,515 acres (37 percent) of this build alternative would cross the Lebo, Tullock, and Tongue River Members of the Fort Union Formation, respectively (Table 13.2-5). The risk of this build alternative crossing bedrock would be the same as the risk described for the Tongue River Alternative.

Soils

The Moon Creek East Alternative would be constructed on excellent to moderately poor soils. Approximately 40 percent of the right-of-way would cross the Rock outcrop-Megonot-Manning-Cambeth-Cabbart association, which has excellent qualities for rail subgrade. The build alternative would also cross soils with the following suitability for construction: good (5 percent), fair to moderately poor (38 percent), and moderately poor (18 percent) (Table 13.2-6). Hydric and sodic soils are not present and the potential for topsoil erosion is expected to be low except for the segment that crosses the Yamac-Delpoint-Cabbart soil association.

Decker Alternatives

Decker Alternative

Topography

The Decker Alternative would be 51.09 miles long. Of this length, 6.27 miles (12 percent) would cross terrain with a slope less than or equal to 1 percent, 19.52 miles (38 percent) would cross terrain with a slope greater than 1 percent and less than or equal to 5 percent, and 25.30 miles(50 percent) would cross terrain with a slope greater than 5 percent (Table 13.2-3).

The Decker Alternative would require 42.77 and 39.71 MCY of cut and fill, respectively, for a total of 82.48 MCY of earth moved or 1.61 MCY of earth moved per mile (Table 13.2-4). This build alternative would require substantial amounts of cut and fill, which would result in permanent physical impacts on the existing topography.

Geology

The total length of the Decker Alternative would be 51.09 miles and the right-of-way would encompass 2,826 acres. Approximately 444 acres (16 percent) and 35 acres (1 percent) of this build alternative would cross Quaternary alluvium and terrace deposits, respectively. Approximately 2,348 acres (83 percent) of this build alternative would cross the Tongue

River Member of the Fort Union Formation (Table 13.2-5). The risk of this build alternative crossing bedrock would be the same as the risk described for the Tongue River Alternative.

Soils

The Decker Alternative would be constructed on fair to moderately poor soils (100 percent). Hydric and sodic soils are not present and the potential for topsoil erosion is expected to be low except for the segment that crosses the Yamac-Delpoint-Cabbart soil association (Table 13.2-6).

Decker East Alternative

Topography

The Decker East Alternative would be 49.63 miles long. Of this length, 5.91 miles (12 percent) would cross terrain with a slope less than or equal to 1 percent, 18.83 miles (38 percent) would cross terrain with a slope greater than 1 percent and less than or equal to 5 percent, and 24.88 miles (50 percent) would cross terrain with a slope greater than 5 percent (Table 13.2-3).

The Decker East Alternative would require 49.76 and 45.75 MCY of cut and fill, respectively, for a total of 95.51 MCY of earth moved or 1.92 MCY of earth moved per mile (Table 13.2-4). This build alternative would require substantial amounts of cut and fill, which would result in permanent physical impacts on the existing topography.

Geology

The total length of the Decker East Alternative would be 49.63 miles and the right-of-way would encompass approximately 2,695 acres. Approximately 359 acres (13 percent) and 35 acres (1 percent) of this build alternative would cross Quaternary alluvium and terrace deposits, respectively. Approximately 2,301 acres (86 percent) of this build alternative would cross the Tongue River Member of the Fort Union Formation (Table 13.2-5). The risk of this build alternative crossing bedrock would be the same as the risk described for the Tongue River Alternative.

Soils

The Decker East Alternative would be constructed on fair to moderately poor soils (100 percent). Hydric and sodic soils are not present along the proposed alignment and the potential for topsoil erosion would be low except for the segment that crosses the Yamac-Delpoint-Cabbart soil association (Table 13.2-6).

13.2.4.3 No-Action Alternative

Under the No-Action Alternative, TRRC would not construct and operate the proposed Tongue River Railroad, and there would be no impacts related to geology and soils from construction or operation of the proposed rail line.

13.2.4.4 Mitigation and Unavoidable Environmental Consequences

To avoid or minimize environmental impacts related to geology and soils from the proposed rail line, OEA is recommending that the Board impose five mitigation measures, including four measures volunteered by TRRC (Chapter 19, Section 19.2.10, *Geology, Soils, and Paleontological Resources*). These measures would require TRRC to design the proposed rail line and facilities to minimize geologic and seismic hazards, implement a stormwater pollution prevention plan and best management practices for stormwater discharge, design the alignment to balance cut and fill requirements, conduct geotechnical investigations to identify slumping risks, and institute remedial actions immediately should slump failure occur.

Even with implementation of OEA's recommended mitigation measures and TRRC's voluntary measures, construction and operation of the proposed rail line would cause unavoidable impacts related to geology and soils. These impacts could include permanent physical alterations of existing topography, geologic formations (bedrock), and soils. Erosion could cause soil and topsoil loss, and a seismic event could damage the tracks, railbed, and access roads. OEA concludes that these adverse impacts would range from negligible to minor, depending on the build alternative.

13.3 Paleontological Resources

This section describes the impacts on paleontological resources that could result from construction and operation of each of the build alternatives. The subsections that follow describe the paleontological resources study area, the methods used to analyze the impacts on paleontological resources, the affected environment, and the impacts of the build alternatives on paleontological resources. The regulations and guidance related to paleontological resources are summarized in Section 13.4, *Applicable Regulations*. The contribution of the proposed rail line to cumulative impacts on paleontological resources is discussed in Chapter 18, *Cumulative Impacts*.

When examining paleontological impacts, the sensitivity of the rock units and sedimentary units crossed and the amount of cutting and earth moving required is more important than the overall length of the alternative. For example, a lengthy alternative that is largely confined to shallow grading and cutting—which would not in most areas be deep enough to encounter paleontological resource—would have a lower potential to affect fossil resources than a shorter alternative that requires more extensive and deeper rock work. The build alternatives that would use an east variation would have higher amounts of cut than their counterparts. For example, the Decker East Alternative, despite being the third shortest build alternative, would have the third highest amount of cut associated with it.

In summary, the Tongue River Alternative and the Tongue River East Alternative would have the most impacts on rock units ranked as highly sensitive for paleontological resources. The Colstrip Alternatives and Decker Alternatives would cross only rock units ranked as moderately sensitive for paleontological resources. The Tongue River Road East Alternative would require the most earthwork, whereas the Colstrip Alternative would require the least. The Tongue River East Alternative, Tongue River Road East Alternative, Moon Creek East Alternative, and Decker East Alternative would require the most earthwork due to cutting associated with the east variation for these build alternatives. OEA concludes that adverse impacts would range from negligible to minor, depending on the build alternative.

13.3.1 Study Area

OEA defined the study area for paleontological resources as the rights-of-way of the build alternatives. The rights-of-way encompass the areas where ground disturbance would occur and where fossils may be discovered.

13.3.2 Analysis Methods

OEA used the following methods and information sources to evaluate the impacts of construction of the build alternatives on paleontological resources.

13.3.2.1 Data Collection

OEA analyzed potential impacts related to paleontology qualitatively, based on a review of available published literature and data. The available resources included geologic and topographic maps and other publications by the U.S. Geological Survey, and information provided by the U.S. Department of the Interior, Bureau of Land Management, Montana State Office and Miles City Field Office (Aaberg 2006, Liggett n.d., Melton pers.comm. 2015a). OEA conducted a literature and locality search at the Montana Historical Society, which also maintains the paleontology locality records for Montana; the U.S. Geological Survey in Menlo Park, California; the Map and Earth Sciences Library at U.C. Berkeley; the University of California Museum of Paleontology online database and GeoRef database (UCMP); and at the Yale Peabody Museum of Natural History, Division of Vertebrate Paleontology (Yale). OEA's analysis focused on the potential for discovering significant fossil resources during construction for each build alternative by mapping the rock units crossed by each build alternative, calculating the amount of acreage encompassed by each rock unit, and analyzing their paleontological sensitivity. The build alternatives with larger areas of high sensitivity would be more likely to undergo greater impacts.

OEA used the volume of cutting needed for each build alternative (i.e., initial disturbance of sediment and rock units in various amounts and to various depths to provide a grade for the railroad) to determine the relative extent of potential impacts to paleontological resources.

13.3.2.2 Sensitivity Analysis

Paleontological-potential levels were assigned to each geological unit using the Potential Fossil Yield Classification (PFYC) System adopted by the Bureau of Land Management (BLM) in 2007 for assessing paleontological potential on federal land (Bureau of Land Management 2008). The PFYC system is a five-tiered system that classifies *geological units*[1] based on the relative abundance of vertebrate fossil or scientifically significant invertebrate and plant fossils and their potential to be adversely affected. The higher class number indicates a higher potential level. This classification system is applied to the geologic formation, member (members are subunits of a geologic formation), or other distinguishable map unit, preferably at the most detailed level possible, because of the direct relationship that exists between paleontological resources and the geologic units in which fossils are located. By knowing the geology of a particular area and the fossil productivity of particular geologic units, it is possible to predict where fossils are likely to be found.

Each class is defined as follows.

- **Class 1 – Very Low**. Geologic units not likely to contain recognizable fossil remains. The probability for affecting any fossils is negligible.

[1] Terms italicized at first use are defined in Chapter 25, *Glossary*.

- **Class 2 – Low**. Sedimentary geologic units not likely to contain vertebrate fossils or scientifically significant *nonvertebrate fossils*. The probability for affecting vertebrate fossils or scientifically significant invertebrate or plant fossils is low.
- **Class 3 – Moderate** or **Unknown**. *Fossiliferous* sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential.
  - **Class 3a – Moderate Potential.** Units are known to contain vertebrate fossils or scientifically significant nonvertebrate fossils, but these occurrences are widely scattered. Common invertebrate or plant fossils may be found in the area. The potential for a project to be sited on or to affect a significant fossil locality is low, but is somewhat higher for common fossils.
  - **Class 3b – Unknown Potential.** Units exhibit geologic features and conditions that suggest significant fossils could be present, but little information about the paleontological resources of the unit or the area is known. This may indicate the unit or area is poorly studied, and field surveys may uncover significant finds. The units in this class may eventually be placed in another class when sufficient survey and research is performed.
- **Class 4 – High**. Geologic units containing a high occurrence of significant fossils. Vertebrate fossils or scientifically significant invertebrate or plant fossils are known to occur and have been documented, but may vary in occurrence and predictability. Surface-disturbing activities may adversely affect paleontological resources in many cases. The probability for affecting significant paleontological resources is moderate to high.
  - **Class 4a**. Geologic units are exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than 2 acres. Paleontological resources may be susceptible to adverse impacts from surface-disturbing actions.
  - **Class 4b**. These are areas underlain by geologic units with high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. The bedrock unit has high potential, but a protective layer of soil, thin alluvial material, or other conditions may lessen or prevent potential impacts on the bedrock resulting from the activity.
- **Class 5 – Very High**. Highly fossiliferous geologic units that consistently and predictably produce vertebrate fossils or scientifically significant invertebrate or plant fossils, and that are at risk of human-caused adverse impacts or natural degradation.
  - **Class 5a**. Geologic units are exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than 2 contiguous acres. Paleontological resources are highly susceptible to adverse impacts from surface-disturbing actions.

- **Class 5b**. These are areas underlain by geologic units with very high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. The bedrock unit has very high potential, but a protective layer of soil, thin alluvial material, or other conditions may lessen or prevent potential impacts on the bedrock resulting from the activity.

13.3.3 Affected Environment

The existing environmental conditions related to paleontological resources are described below.

13.3.3.1 Paleontological Locality Search

The build alternatives are within the known fossiliferous Paleocene fluvio-lacustrine Fort Union Formation, which is about 66 to 64 million years old (Jacob 1973, Ross and Witkind 1955). This point in time marks the Cretaceous-Tertiary (KT) boundary, about 65 million years ago, as evidenced by the vanishing of the dinosaurs and the onset of mammalian, insect, and plant fauna (Douglass 1908; Gidley 1923; Hannemand and Widemann 1991; McKenna 1963). Also present at the northern terminus of the proposed rail line are potentially fossiliferous Pleistocene deposits.

In the Fort Union Formation, the UCMP indicates there are 30 known paleontological recorded sites/localities in Custer County, 20 paleontological sites/localities in Powder River County, and one paleontological site/locality in Rosebud County. The Yale database indicated that there are 621 localities recorded in Custer County from the Fort Union Formation. One paleobotanical (fossil plant) locality is reported in the Fort Union Formation near the Project alternatives near Miles City. Locality information is given in terms of counties, vague location descriptions and in general terms to the nearest town or city. Known fossil localities are at some distance from the build alternatives, since they are located on private and public land that likely has never been systematically examined for fossil resources.

Pleistocene deposits in the study area, especially in the project area's northern portion near the mouth of the Tongue River, are documented to contain plant remains and mammoth fossils (Melton pers. comm. 2015b). Although the fossil potential for these deposits is moderate, the likelihood that the fossils would be considered significant is high.

BLM records indicate that paleontological resources have been recorded near the Decker Alternative near Birney and at the Spring Creek Mine. These consist of plant and invertebrate fossils, although one of the plant fossils at Spring Creek also contains amphibian bone fragments. Also, just north of the Colstrip Alternative, the State University of New York recorded 13 or more vertebrate fossil localities in the Lebo Member of the Fort Union Formation in the Rosebud Creek Valley.

The records search at the Montana Historical Society conducted in 2013 yielded one fossil resource, located about 1 mile east of the Tongue River Alternative. This locality, 24CR0144, was described as the remains of a marine reptile fossil.

One fossil resource (Figure 13.3-1) was found during a 2013 cultural resources survey of the Tongue River Alternative. This singleleaf fossil, 24RB2679, was found on a small cobble on an abandoned road.

Figure 13.3-1. Leaf Fossil Found during Survey

Regionally, significant fossil localities in the surrounding area from the Fort Union Formation are found in the cities and communities of Cokedale, Bear Creek, Mexican Hat, Glendive (plant localities), and Hogan Creek (extinct turtle fossils) (Knowlton 1909, Dorf 1940, Joyce et al. 2009, Roberts 1972, Flores 1987, Wilf et al. 2006). These localities are approximately 80 to 180 miles from the build alternatives. A locality exists in Miles City at the mouth of the Tongue River, near the Tongue River Alternatives and Tongue River Road Alternatives (Knowlton 1909). The mouth of the Tongue River near Miles City is known to have yielded Pleistocene megafauna remains (Melton pers. comm 2015a). For the Moon Creek Alternatives, there are fossil plant localities in the nearby Forsyth area (Knowlton 1909). There are many fossil plant localities in the Bighorn, Montana area, approximately 10 to 30 miles south of the proposed rail line (Knowlton 1909). The Mexican Hill locality southeast of the project area in the Fort Union Formation contains post-KT boundary insects and abundance flora (McKenna 1963, Wilf et al. 2006). Unique turtle and primate mammals (shrews [*Aidunator*] and, extinct rodent-like mammals [*Anconodon*], and others) occur in the Fort Union Formation and are regarded as very significant due to their place in geologic and evolutionary time (Knowlton 1909, Simpson 1935–1937, Dorf 1940, Gingerich 1975, Holtzman 1976, Holtzman and Wolberg 1977, Flores 1987, Wilf et al. 2006).

13.3.3.2 Paleontological Sensitivity of Rock Units

Rock units and sedimentary units that would be crossed by the build alternatives have been assigned a sensitivity ranking using the PFYC system (Bureau of Land Management 2008). A draft report of PFYCs for Montana (Liggett n.d.) has been prepared recently, and is considered preliminary. This report suggests that local conditions can affect PFYC. Therefore, the present document will use PFYC information provided by the Miles City BLM office, since that assessment is based on less generalized local conditions.

The draft report of PFYCs for Montana (Liggett n.d.) states that all members of the Fort Union Formation—the Tullock, Lebo, and Tongue River Members—fall into PFYC 5. However, on a case-by-case basis it may be warranted to give the units a PFYC less than 4. The Miles City BLM office, considering local conditions, classifies the Lebo and Tongue River members as PFYC 3, with the Tullock Member categorized as PFYC 4 (Melton pers. comm. 2015a; Aaberg 2006:149). This formation is not present in the Colstrip Alternatives or Decker Alternatives.

The BLM draft report (Liggett n.d.) states that unconsolidated Quaternary Alluvium should be treated on a case-by-case basis, but suggests a range of PFYC of 2 through 4, depending on local conditions. The Miles City BLM office considers Quaternary Alluvium and Quaternary Alluvial Terrace Deposits as PFYC 3 geologic units; these units have a moderate potential for fossil resources as described under PFYC 3a. For example, significant vertebrate fossils have been found in Quaternary deposits near the mouth of the Tongue River. These types of finds are significant, but are also widely scattered.

Class 3 rock units and sedimentary units fall under PFYC 3b, having an unknown potential to encompass fossil resources. As described by the PFYC system, these units within the build alternatives exhibit geologic features and conditions that suggest significant fossils could be present, but little information about the paleontological resources of the area is presently known. Because much of the land in the project area is privately held, many extensive areas have not been investigated for paleontological resources.

13.3.4 Environmental Consequences

Impacts on paleontological resources could result from construction and operation of the build alternatives. The impacts common to all build alternatives are presented first, followed by impacts specific to the build alternatives.

13.3.4.1 Impacts Common to All Build Alternatives

Construction

Most build alternatives would cross the three distinct members of the Fort Union Formation and could encounter bedrock at varying depths and locations during rail line construction. As noted above, the Tullock member is not present in the Colstrip Alternatives or Decker Alternatives.

Construction of any build alternative would require removal of bedrock to maintain grade and a suitable foundation. Excavation of bedrock with conventional machinery or blasting would be required. Quaternary Alluvium and Quaternary Alluvial Terrace Deposits would also be affected, by grading and excavation. Impacts on sensitive paleontological resources possibly present in geologic formations are discussed in Section 13.3.4.2, *Impacts by Build Alternative*.

Operation

Operation of the proposed rail line would have no direct impacts on paleontological resources. A potential indirect impact would be use of the railroad right-of-way to access new exposures of bedrock in railroad cuts. This could result in illegal fossil collection and damage to significant resources.

13.3.4.2 Impacts by Build Alternative

The impacts related to paleontological resources that are specific to each build alternative are described below, and are represented in the following tables and figures.

- Table 13.3-1 identifies the geologic formations that each build alternative would traverse, and their associated classification per the PFYC system.
- Table 13.3-2 summarizes the total and average amount of material that would be cut per mile of right-of-way, by build alternative.

Table 13.3-1. Paleontological Sensitivity by Alternative in the Geological Study Area

Build Alternative	Total Acres	Qal (acres)	Qal (%)[a]	Qat (acres)	Qat (%)[a]	Tfle (acres)	Tfle (%)[a]	Tft (acres)	Tft (%)[a]	Tftr (acres)	Tftr (%)[a]
PFYC		**3**	**--**	**3**	**--**	**3**	**--**	**4**	**--**	**3**	**--**
Tongue River	3,783	450	12	242	6	498	13	1,283	34	1,311	35
Tongue River East	3,803	257	7	251	7	498	13	1,283	34	1,515	40
Colstrip	2,040	419	21	-	-	-	-	-	-	1,621	79
Colstrip East	2,094	207	10	36	2	-	-	-	-	1,850	88
Tongue River Road	4,234	470	11	313	7	1,002	24	1,153	27	1,296	31
Tongue River Road East	4,218	274	6	292	7	1,002	24	1,153	27	1,497	35
Moon Creek	4,026	486	12	96	2	797	20	1,336	33	1,311	33
Moon Creek East	4,047	293	7	105	3	797	20	1,336	33	1,515	37
Decker	2,826	444	16	35	1	-	-	-	-	2,348	83
Decker East	2,695	359	13	35	1	-	-	-	-	2,301	85

Notes:

[a] Rounding error may result in a total slightly different than 100%

Qal = Quaternary Alluvium (Qat = Quaternary Alluvium Terrace Deposit; Tfle = Lebo Member of Fort Union Formation; Tft = Tullock Member of Fort Union Formation; Tftr = Tongue River Member of Fort Union Formation

Table 13.3-2. Cut Requirements by Build Alternative

Build Alternative	Cut (MCY)	Length of Build Alternative (miles)	Average Cut per Mile (MCY/mile)
Tongue River	25.30	84.06	0.30
Tongue River East	41.59	86.36	0.48
Colstrip	18.20	42.30	0.43
Colstrip East	34.48	45.13	0.76
Tongue River Road	38.80	84.00	0.46
Tongue River Road East	55.09	85.97	0.64
Moon Creek	36.20	82.44	0.44
Moon Creek East	52.49	84.75	0.62
Decker	42.77	51.14	0.84
Decker East	49.76	49.68	1.00

Notes:
MCY = million cubic yards

Tongue River Alternatives

Tongue River Alternative

The Tongue River Alternative would be 84.06 miles long and the right-of-way would encompass 3,783 acres. Approximately 2,501 acres (66 percent) would cross PFYC 3 surficial rock units, consisting of Quaternary deposits, and the Lebo and Tongue River Members of the Fort Union Formation (Table 13.3-1). Approximately 1,283 acres (34 percent) of this build alternative would cross the Tullock of the Fort Union Formation (PFYC 4) (Table 13.3-1). This build alternative would encounter bedrock at varying depths and locations in any of the three distinct members of the Fort Union Formation, as well as require grading and excavation in the Quaternary alluvium and terrace deposits.

The Tongue River Alternative would require 25.30 million cubic yards of cut and earthwork, or 0.30 million cubic yard of earth moved per mile (Table 13.3-2). This build alternative would require the second-least amount of cutting by volume; however, 34 percent of this would take place in the high-sensitivity Tullock Member of the Fort Union Formation (PFYC 4), which could result in permanent physical impacts on paleontological resources.

Tongue River East Alternative

The Tongue River East Alternative would be 86.36 miles long and the right-of-way would encompass 3,803 acres. Approximately 2,521 acres (66 percent) would cross PFYC 3 surficial rock units, consisting of Quaternary deposits, and the Lebo and Tongue River Members of the Fort Union Formation (Table 13.3-1). Approximately 1,283 acres (34 percent) of this build alternative would cross the Tullock Member of the Fort Union Formation (PFYC 4) (Table 13.3-1). This build alternative would encounter bedrock at varying depths and locations in any of the three distinct members of the Fort Union

Formation. It would also require grading and excavation in the Quaternary alluvium and terrace deposits.

The Tongue River East Alternative would require 41.59 million cubic yards of cut and earthmoving or 0.48 million cubic yard of earth moved per mile (Table 13.3-2). This build alternative would require the sixth-most amount of cutting by volume, and 34 percent of this would take place in high-sensitivity Tullock Member of the Fort Union Formation (PFYC 4), which could result in permanent physical impacts on paleontological resources.

Colstrip Alternatives

Colstrip Alternative

The Colstrip Alternative would be 42.30 miles long and the right-of-way would encompass 2,040 acres. The entirety of this build alternative would cross PFYC 3 surficial rock units consisting of Quaternary deposits and the Tongue River Member of the Fort Union Formation (Table 13.3-1).

The Colstrip Alternative would require 18.20 million cubic yards of cut and earthwork or 0.43 million cubic yard of earth moved per mile (Table 13.3-2). This build alternative would require the least amount of cutting and earth-moving activity. Although this earth moving would occur in moderately sensitive rock units, there could be permanent physical impacts on paleontological resources.

Colstrip East Alternative

The Colstrip East Alternative would be 45.13 miles and the right-of-way would encompass 2,094 acres. The entirety of this build alternative would cross PFYC 3 surficial rock units consisting of Quaternary deposits and the Tongue River Member of the Fort Union Formation (Table 13.3-1).

The Colstrip East Alternative would require 34.48 million cubic yards of cut and earthwork or 0.76 million cubic yard of earth moved per mile (Table 13.3-2). This build alternative would require more cutting and earthmoving than the Colstrip Alternative. This build alternative would require the third-least amount of cutting by volume. Although this earthmoving would occur in moderately sensitive rock units, there could be permanent physical impacts on paleontological resources.

Tongue River Road Alternatives

Tongue River Road Alternative

The Tongue River Road Alternative would be 84.00 miles and the right-of-way would encompass 4,234 acres. Approximately 3,081 acres (73 percent) would cross PFYC 3 surficial rock units consisting of Quaternary deposits, and the Lebo and Tongue River Members of the Fort Union Formation (Table 13.3-1). Approximately 1,153 acres (27 percent) of this build alternative would cross the Tullock Member of the Fort Union Formation (PFYC 4) (Table 13.3-1). This build alternative would encounter bedrock at varying depths and locations in any of the three distinct members of the Fort Union Formation, as well as require grading and excavation in the Quaternary alluvium and terrace deposits.

The Tongue River Road Alternative would require 38.80 million cubic yards of cut and earthwork or 0.46 million cubic yard of earth moved per mile (Table 13.3-2). This build alternative would require the fifth-most amount of cutting by volume, and 27 percent of this would take place in the high-sensitivity Tullock Member of the Fort Union Formation (PFYC 4), which could result in permanent physical impacts on paleontological resources.

Tongue River Road East Alternative

The Tongue River Road East Alternative would be 85.92 miles long. The right-of-way would encompass 4,218 acres, of which approximately 3,065 acres (73 percent) would cross PFYC 3 surficial rock units consisting of Quaternary deposits and the Lebo and Tongue River Members of the Fort Union Formation (Table 13.3-1). Approximately 1,153 acres (27 percent) of this build alternative would cross the Tullock Member of the Fort Union Formation (PFYC 4) (Table 13.3-1). This build alternative would encounter bedrock at varying depths and locations in any of the three distinct members of the Fort Union Formation, as well as require grading and excavation in the Quaternary alluvium and terrace deposits.

The Tongue River Road East Alternative would require 55.09 million cubic yards of cut and earthwork or 0.64 million cubic yard of earth moved per mile (Table 13.3-2). This build alternative would require the most cutting and earth-moving activity, and 27 percent of this would take place in the high-sensitivity Tullock Member of the Fort Union Formation (PFYC 4), which could result in permanent physical impacts on paleontological resources.

Moon Creek Alternatives

Moon Creek Alternative

The Moon Creek Alternative would be 82.44 miles long and the right-of-way would encompass 4,026 acres. Of these, approximately 2,690 acres (67 percent) would cross PFYC 3 surficial rock units consisting of Quaternary deposits and the Lebo and Tongue River Members of the Fort Union Formation (Table 13.3-1). Approximately 1,336 acres (33 percent) of this build alternative would cross the igh-sensitivity Tullock Member of the Fort Union Formation (PFYC 4) (Table 13.3-1). This build alternative would encounter bedrock at varying depths and locations in any of the three distinct members of the Fort Union Formation, as well as require grading and excavation in the Quaternary alluvium and terrace deposits.

The Moon Creek Alternative would require 36.20 million cubic yards of cut and earthwork or 0.44 million cubic yard of earth moved per mile (Table 13.3-2). This build alternative would require the fourth-least amount of cutting by volume; however, 33 percent of this would take place in the high-sensitivity Tullock Member of the Fort Union Formation (PFYC 4), which could result in permanent physical impacts on paleontological resources.

Moon Creek East Alternative

The Moon Creek East Alternative would be 84.75 miles long and the right-of-way would encompass 4,047 acres. Approximately 2710 acres (67 percent) would cross PFYC 3 surficial rock units consisting of Quaternary deposits and the Lebo and Tongue River Members of the Fort Union Formation (Table 13.3-1). Approximately 1,336 acres (33 percent) of this build alternative would cross the high-sensitivity Tullock Member of the Fort Union Formation (PFYC 4) (Table 13.3-1). This build alternative would encounter bedrock at varying depths and locations in any of the three distinct members of the Fort Union Formation, as well as require grading and excavation in the Quaternary alluvium and terrace deposits.

The Moon Creek East Alternative would require 52.49 million cubic yards of cut and earth moving or 0.62 million cubic yard of earth moved per mile (Table 13.3-2). This build alternative would require the second-most amount of cutting and earthmoving, of which 33 percent would take place in the high-sensitivity Tullock Member of the Fort Union Formation (PFYC 4), which could result in permanent physical impacts on paleontological resources.

Decker Alternatives

Decker Alternative

The Decker Alternative would be 51.44 miles long and the right-of-way would encompass 2,826 acres. The entirety of this build alternative would cross PFYC 3 surficial rock units consisting of Quaternary deposits and the Tongue River Member of the Fort Union Formation (Table 13.3-1).

The Decker Alternative would require 42.77 million cubic yards of cut and earthmoving or 0.84 million cubic yard of earth moved per mile (Table 13.3-2). This build alternative would require the third-most amount of cutting by volume. Although this earthmoving would occur in moderately sensitive rock units, permanent physical impacts on paleontological resources could occur.

Decker East Alternative

The Decker East Alternative would be 49.76 miles long and the right-of-way would encompass approximately 2,695 acres. The entirety of this build alternative would cross

PFYC 3 surficial rock units, consisting of Quaternary deposits, and the Tongue River Member of the Fort Union Formation (Table 13.3-1).

The Decker East Alternative would require 49.76 million cubic yards of cut and earthmoving, or 1.00 million cubic yard of earth moved per mile (Table 13.3-2). This build alternative would require the second-most amount of cutting and earthmoving. Although this earth moving would occur in moderately sensitive rock units, given this volume of disturbance, permanent physical impacts on paleontological resources could occur.

13.3.4.3 No-Action Alternative

Under the No-Action Alternative, TRRC would not construct and operate the proposed Tongue River Railroad, and there would be no impacts on paleontological resources from construction or operation of the proposed rail line.

13.3.4.4 Mitigation and Unavoidable Environmental Consequences

To avoid or minimize environmental impacts on paleontological resources from construction and operation of the proposed rail line, OEA is recommending that the Board impose one mitigation measure (Chapter 19, Section 19.2.10, *Geology, Soils, and Paleontological Resources*). This measure would require TRRC to consult with a qualified paleontologist to develop and implement a plan to mitigate potential adverse impacts on paleontological resources on state or federal lands classified as PFYC 4 or PFYC 5.

Even with the implementation of OEA's recommended mitigation measure, construction of the proposed rail line would cause unavoidable impacts on paleontological resources. These impacts could include loss of significant paleontological resources during construction. OEA concludes that these adverse impacts would range from negligible to minor, depending on the build alternative.

13.4 Applicable Regulations

Different federal, state, and local jurisdictions are responsible for the regulation of projects that would affect geology, soils, and paleontological resources. These jurisdictions and the regulations, statutes, and guidance that govern geology, soils, and paleontological resources are described in Table 13.4-1.

Table 13.4-1. Regulations, Statutes, and Guidance Related to Geology, Soils, and Paleontological Resources

Regulation	Explanation
Federal	
National Environmental Policy Act (42 U.S.C. § 4321 *et seq.*)	Requires the consideration of potential environmental effects, including potential effects of (or on) contaminated sites in the environmental impact statement for any proposed major federal agency action. NEPA implementation procedures are set forth in the President's Council on Environmental Quality's Regulations for Implementing NEPA (40 C.F.R. Part 1500).
Omnibus Public Lands Act of 2009, Subtitle D—Paleontological Resources Preservation (16 U.S.C. § 470aaa *et seq.*)	Requires that paleontological resources on federal lands be managed using scientific principles and expertise.
Federal Land Policy and Management Act of 1979 (43 U.S.C §§ 1701–1704)	Requires that federal lands be managed to protect the quality of all resources
International Building Code	Replaced earlier regional building codes (including the Uniform Building Code) in 2000 and established consistent national construction guidelines. National model codes are incorporated by reference into the building codes of local municipalities, such as the Montana Building Code, which considers the state's seismic conditions. The IBC would be applicable to proposed buildings and structures.
State	
Montana Building Code (50 MCA Chapter 60)	Sets criteria for proposed buildings and structures based on minimum standards established in the IBC.
Local	
No local regulations or statutes apply to geology and soils.	

Notes:
U.S.C. = United States Code; NEPA = National Environmental Policy Act; C.F.R. = Code of Federal Regulations; IBC = International Building Code; MCA = Montana Code Annotated